ACME Computing Facility

Advanced Computer for Medical Research

Stanford University School of Medicine

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Name of Institution's Biotechnology Resource Advisory Committee:

ACME Policy Committee

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TABLE OF CONTENTS

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INTRODUCTION

ACME, Advance Computer for MEdical Research, is about to conclude its sixth year as a research, development, and service facility. One year ago, a fifteen month administrative extension was requested to become effective August 1, 1972. After discussion with NIH, our fifteen month extension request was reduced to twelve months.

This annual report describes the accomplishments of the past year and proposes a new work program for the fiscal year 1973. We expect this to be the final year of NIH support for ACME under this grant. A new competing proposal has been submitted separately for the creation of a new research resource at Stanford. The primary task to be accomplished under the last year of the ACME grant is preparation for the transition to a service facility whose operating costs, hopefully, will be totally recovered from user fees.

During the past several months, a number of faculty members have contributed actively to long term computer planning for the Medical Center. One question still under review is a proposed merger of an academic service-computing facility such as ACME with the Hospital Data Processing facility. A parallel but separate planning effort is embodied in a proposal for "SUMEX" (Stanford University Medical Experimentation Computer Facility), a new research resource for computer-science research on bio-medical problems. At the university level, planning has dealt with the interrelationships among Medical Center, university administration, and all other campus computing. A brief description of several of these planning activities is incorporated in this report.

I. SUMMARY

A. Highlights of Fiscal Year, 1972

The most significant accomplishment of the past fiscal year has been the active involvement of the faculty and technical staff in planning the future of computing at the Stanford Medical Center. Although the long range-plans have not been completed, considerable progress has been made, resulting in a far better understanding of our current and future needs.

The long-term viability of ACME, viewed as a service facility for the Medical Center, is tied to its ability to earn income sufficient to cover cost. In mid-April, 1972, a new rate schedule became effective for ACME users. Monthly income in the last three months of this fiscal year, is expected to reach an average of $40,000. This figure includes both computer service income, which reverts to the grant budget, and terminal service income, which is handled outside of the ACME grant. Several major users have developed new systems on ACME which will be moved to dedicated standalone systems in production mode. As soon as these dedicated systems are available, income from these sources will drop. On the other hand, one can expect that new applications will continue to be developed which in turn will generate new income.

Service on the ACME facility has been markedly improved in the past fiscal year by the installation of new hardware and software. New hardware includes faster bulk core, a small machine interface capable of handling up to 16 satellites, faster access disk drives, an initial complement for the small machine equipment pool, a terminal controller that will support multiple terminal speeds, and new graphics hardware. Software improvements include improvements to the realtime system, extended graphics support, improved text editing, additional terminal support, improved small machine support, file support, and compiler improvements.

Several new and interesting user projects were implemented during the past year. Some of the more interesting new projects include Dr. Green's activity in Biological Science, Dr. Kadis in Anethesia, Dr. Tatton in Biological Science, Dr. Lawrence William in Oncology, and Dr. Jerome Gold in Diagnostic Radiology. These projects are described in the project descriptions in Section VII.

Continuing user projects include the DENDRAL project, which has connected a new Varian mass-spectrometer to the ACME system and has used the General Purpose Graphics Terminals (developed by Dr. Shipton at University of Iowa) to actively support spectrometer operations. Also, Dr. Stanley Cohen's drug interaction project has received considerable program assistance during the past year. His project, formerly part of ACME's core research activity, received independent funding in November of 1971. A close cooperation between ACME and the drug interaction project continues. Dr. James Fries in Immunology has continued to develop his time-oriented medical record concept. His system has received good acceptance among physicians in the rheumatic clinics and is being actively considered for implementation by other departments (Oncology, Cardiology, and Hematology). The Oncology Department has recently started data entry under programs designed to use the time-oriented medical record.

Utilization of ACME has risen only slightly during the past year. However, this is considered highly satisfactory since the amount of subsidized usage has decreased markedly while the amount of paid usage has increased. Also, since the basic service charge is measured as pages of occupied core times minutes used, installation of a faster core box necessarily resulted in more computing accomplished in a fewer number of pageminutes.

B. Goals for Fiscal Year, 1973

A summary listing of objectives for fiscal year 1973 are presented below:

1. Determine a list of new services required under ACME to assist in improvement of the income posture; Then freeze the system after essential changes are made.

2. Identify critical planning areas for mounting an interactive PL language on the proposed SUMEX System (a DEC PDP-10). Improve the documentation of the ACME system in those areas that will be required to assist in the transition.

3. Actively support the activities of the Stanford Medical Center Computer Planning Committee.

4. Improve small machine support, especially by assisting users in taking advantage of the new small machine multiplexor.

5. Provide batch services to better utilize the night shift hours.

6. Assist in coordination of a project to generalize programs for the time-oriented medical records system so that multiple departments can share in its use.

7. Select commercially available hardware to replace existing terminals and other peripheral units when performance improvements can be realized at cost effective prices. Attempt to make the use of ACME more cost effective wherever possible.

8. Explore the offering of PL/ACME services to potential users at other institutions through commerical communications systems such as TYMNET. Operational ramifications that might result from such an offering will be discussed with Biotechnology Resources Branch.

In summary these objectives call for provision of new services that will attract added income, the freeze and documentation of the existing system, the release of staff time to work on transitions to future systems, and for attracting and assisting new users.

C. Comment on Medical Center Computer Planning

The Stanford Medical Center consists of the Medical School, Hospital, and Out-Patient Clinics. Computing within the Medical School is handled primarily by the ACME facility plus a number of dedicated standalone systems, some of which are connected to ACME. Hospital computing is handled by an administrative data processing facility operating an IBM 360/40. The bulk of the out-patient clinic computing is currently handled by the University Administrative Data Processing Facility on an IBM 370/145. This distribution of the computing load has not proven satisfactory to the user community. A number of alternatives are being explored.

The role of ACME during the past three years has been to provide computing services to faculty and staff researchers in the Medical Center. Earlier the role of ACME was to develop new techniques for offering such services. As the number of users has grown, demand has increased for highly reliable, stable, and available service. For this reason the development effort of the ACME facility has shifted to extensions and improvements to existing facilities rather than radical

changes which would severely impact availability of routine service computing. To provide a research system which can tackle problems associated with high data rate realtime research is the subject of a separate proposal recently submitted. This proposal calls for the creation of a dual processor facility in which one processor and its peripherals are dedicated to providing service to the medical community, while the second processor will be dedicated to a small number of research groups.

The organization of the planning effort, current status, and a brief discussion of some of the alternatives under consideration are briefly described in Section II.

D. Overview of Six-Year ACME Experiment

In the past six years, the NIH-sponsored ACME experiment has accomplished the following:

1. A computing system that is remarkably easy to learn and to use has been designed and built.

2. More than 230 user projects, exclusive of ACME staff, are current users of the system.

3. The system provides a highly interactive time-sharing service and realtime data acquisition. The data collection capabilities are limited to data rates which, in light of current technology, appear slow and limited. Problems of closed loop applications have not been satisfactorily resolved using the 360/50, primarily due to its architecture and other inherent limitations.

4. More than 500 MD's have been trained in the use of this system. Many MD's performing research at Stanford now do their own programming at an ACME terminal.

5. Small machine support from ACME is limited but growing.

We have learned in the past six years that computer science-type research which can involve frequent hardware adjustments and changes, as well as systems software changes, cannot be performed effectively on a resource which routinely provides service for the balance of the community. Conflicts over resource allocation between research oriented as opposed to service oriented users lead to compromises unacceptable to one or both groups.

The rapid advance of small machines was not anticipated at the time of the original ACME proposal. This mini revolution has provided faster, better, more economical systems, including broader peripheral support, than we envisioned in 1965-66. We continue to see a role, at least for the next three to five years, for the large central processor, assuming that its resources are supplemented with a number of satellite computing systems to handle special requirements.

A problem which we have been unable to resolve is how to provide free computing to pilot projects around the Medical Center. We've observed that a number of the pioneering computer efforts have been possible only by viture of the free computing provided under the ACME grant. As the need to provide self-sufficiency increased, we were able to approve fewer new pilot projects each year. We strongly urge that NIH waive one of its policy restrictions for the coming fiscal year,so that ACME can continue to encourage the development of new concepts on a pilot basis through non-chargeable computing services. The University in turn must determine some method of funding such usage when there is no longer an ACME grant behind the service system.

Computer users nationwide are learning that the software costs (both systems and applications) far exceed the hardware costs in most installations. The significant investment forces consideration of major transition costs when converting to new hardware or software systems. We have learned that we would like to use manufacturer's supported software whenever possible to provide maximum exportability to other institutions. We also observe a trend in which software will become an increasing percentage of the total computing picture. Therefore, we would like to see more integration of resources within the Medical Center so that personnel need not be trained on multiple hardware and software systems, and they will not be required to reprogram their efforts.

II. STANFORD MEDICAL CENTER COMPUTING PLANS

A. The Medical Center Scene

During the past fiscal year, Dr. Clayton Rich, was appointed Dean of the Medical School. He has expressed concern for the long-range planning of computing in the Medical Center. Recently, a new faculty position was created in the Department of Community Medicine for appointing an M.D. with a strong interest in problems associated with service computing in a medical environment. In January, 1972, Dean Rich established a Medical Center Computer Facilities Planning Committee and charged it with the responsibility of examining the feasibility of merging the ACME facility with the Hospital Data Processing facility. To date, the Committee has spent the bulk of its effort examining alternative organizations and configurations and identifying service requirements. Hopefully, by early fall, the Committee will be prepared to recommend specific actions to the Dean. ACME staff members will provide technical support to the Committee's deliberations.

B. ACME Follow-on Grant

The SUMEX proposal calls for creating a high data-oriented resource using a PDP-10 as the host computer. Dr. Lederberg, who is Principal Investigator of the new proposal, has suggested that the service system for the Medical Center be a hardware configuration similar to the research system. In this way, developments occurring on the research system can be moved readily to the service system. It also provides a strong back-up capability for the service system. One thing learned at ACME is that Medical Center personnel place a high value on reliability and availability. Only by having a back-up system can the kinds of requirements frequently cited here be met.

The impact of the proposed research system on ACME's plans for the coming year is reflected in the decision to freeze the ACME system design as soon as possible, tie together the loose ends through documentation, and move on to efforts that will smooth the transition to another hardware system. Other demonstrations of the impact on our planning are as follows:

1. The current staff will require training on PDP-10 hardware and software systems.

2. Planning which in the past has been based upon IBM hardware selection will have to be modified.

3. Increasing the income of the service facility requires development of more usage and more users. The creation of a new research facility will dilute the funding base to some extent.

4. A consensus must be reached concerning the long range plans for the Medical Center so that users of the existing ACME facility will not be motivated to develop dedicated stand-alone systems for all applications. The Dean of the Medical School will be expected to make some firm commitments in order to avoid confusion and uncertainity over the existence of a large service center.

III. ACME FACILITY ACCOMPLISHMENTS, 1972

Accomplishments by staff Operations, Systems, and Applications groups and efforts supporting Medical Center planning are described. User core research progress notes are included in the section entitled 'Project Descriptions'.

Last year's report indicated that two factors were shaping changes in ACME. The first was financial and the second involved a choice between serving special research versus general computer users. Efforts to solve the financial problem necessitated the substitution of faster bulk core, which increased our capacity significantly while only slightly increasing costs. By adding capacity we have been able to offer services to more users within the Stanford medical community. In addition, rate adjustments have been announced which will help us determine the viability of ACME in a market situation where prices are set close to actual cost of providing service.

A. Planning Studies

1. ACME/Campus Merger Study

Last fall, a study was conducted to determine the feasibility of merging ACME with the Stanford Campus Facility. The study focused on (1) the capacity of the Campus 360/67 to absorb the ACME load; (2) an overview of service and cost considerations; (3) a review of planned changes within the Campus Facility; and (4) the relative advantages and disadvantages of a merger. A number of problems were identified which resulted in further consideration of merging Hospital and ACME computing facilities rather than Campus and ACME facilities. Some notes on the ACME/Campus merger study were issued in the form of a technical note, ACM, a copy of which is enclosed as Appendix A.

2. Comparision of Available Time-Sharing Systems

The IBM systems TSO, CPS, and CALL-OS are under review as to their possible application to Stanford medical computing. Some specific questions to be answered are the language differences between the various PL/I subsets, the magnitude of the conversion problem from PL/ACME to another PL/I dialect, hardware requirements for approximately 50 terminals, and some of the specific pros and cons associated with each system.

3. Alternative Hardware Proposals

Gio Weiderhold, Tom Rindfleisch and Chuck Dickens were asked to suggest a limited number of feasible hardware configurations for consideration by the Medical Center Computer Facilities Planning Committee. The purpose of this request was to limit the amount of decision space to be actively considered. The seven alternatives suggested by the subcommittee included a large IBM processor, a dual IBM configuration, a large DEC processor with satellite systems, a highly distributed computing system, finally the purchase of essentially all services from outside sources. The MCCFPC has rejected four of the seven alternatives and continues to study the remaining three. The new proposal, recently submitted by J. Lederberg, calls for a dual PDP-10 configuration in which one machine is primarily a research support machine and the second machine is a service system.

There has not been adequate time to date for detailed review of this topology by the MCCFPC. One of the more significant problems envisioned with this topology is the existence of a large number of second generation programs currently operating on IBM hardware supported under DOS. Even if these programs were converted to COBOL, it is not clear that the Hospital would choose to run on hardware other than IBM. However, a fairly small IBM machine might absorb the load, while coupled to the patient data base and to a PDP-10. Clearly the MCCFPC has some difficult problems to resolve over the next several months.

4. Small Machine Support Study

The ACME systems staff, in cooperation with staff members of other SCC facilities, formalized current ideas on the types of services required of a large host computer to adequately support a variety of satellite machines. A summary of the study was published as ACME Technical Note PSCS and is included as Appendix E. A few of the salient features are a 'front-end' networking switch, continuous spooling service, the capability of the satellite computer to act as a master terminal, and high level language processors.

B. New and Continuing Application Programs

1. DENDRAL

The ACME facility attempted to support the DENDRAL project in a number of ways during the past fiscal year. One approach at supporting DENDRAL has failed. An interactive LISP compiler was mounted under PL/ACME. Although the compiler runs and can be used, it is too slow for the large programs which the DENDRAL project tend to execute. Furthermore, the compiler is not identical to the batch version which imposes limitations on the user. More successful have been the efforts to support with hardware and software the 315C General Purpose Graphics Terminals. Using the tools provided, DENDRAL programmers have written a rather complete set of operator aids using a GPGT. In addition, a remote job entry system for overnight batch jobs has been partially prepared during the month of May. It is hoped that this service will be offered routinely in June, and that it will subsequently be improved to be more flexible in general. Limited assistance was provided in planning the long-term needs of the DENDRAL project for computing. Finally, the DENDRAL staff has been very helpful to ACME in identifying and solving realtime support problems.

2. Drug Interaction Project

The data entry and label printing program was placed into production in the Hospital Pharmacy last September. Two CRT devices and two printers are used for entering perscription information into a central patient file and for subsequent perscription label printing.

The second phase of the project will implement automatic drug interaction searches and reporting of detected interactions to the physician. Incorporation of interaction searches into the production pharmacy system is imminent.

3. Oncology Time-Oriented Records

Members of the ACME staff have applied the concept of Dr. James Fries' time-oriented medical records to computerization of the Department of Oncology patient files. Both narrative and numerical data are collected and presented in a three-dimensional form (patient, medical measurements, and time).

Initially, four programs have been developed. A patient record input program allows for item entry in either a serial manner or in an operator-determined sequence. A second program automates specific item editing on the file. The third and fourth programs generate letters to referring physicians, describing the current status of each patient's diagnosis as determined by the time-dependent visits to the Oncology Clinic.

Ultimately, we plan to incorporate the data bank analysis programs of Dr. Fries into this project.

4. New Realtime Projects

Several new realtime users joined us last year. William Tatton, Stanford Department of Biological Sciences (P. I., Donald Perkel) is engaged in a study of the characteristics of neural circuits underlying behavior and sensory information processing in both mammal and invertebrate nervous systems. Dr. Paul Green, also of the Department of Biological Sciences, is analyzing the growth process of plants. Growth rate is measured as a function of step shifts in the turgor pressure. The system is a model for the study of mechanisms for cessation of growth in man.

Doctors Walton Roth and Leslie Kadis are both studying EEG data, but for differing purposes. Dr. Kadis, Department of Anethesia, was awarded a pilot project for a psycho-physiological study of tolerance to experimental pain. Normal college-age students are subjects for collection of data relevant to an individual's pain threshold, response to drugs, etc. Dr. Roth of the Palo Alto Veterans Administration Hospital, Dept. of Psychiatry, is processing EEG data for statistical analysis of measures derived from special purpose machines.

5. CSMP Design Study

A design specification for inclusion of an interactive Continuous System Modelling Program (CSMP) in the ACME system has been published as ACME Technical Note CSMPI. Model definition is accomplished by standard CSMP language statements with PL/ACME statements intermixed in the program. Processing is in three stages: (1) translation of the CSMP model to a PL/ACME program equivalent, (2) compilation of the PL/ACME program, and (3) execution. Plans for implementation are in abeyance at this time.

6. Radiation Therapy Programs

An information retrieval program was written for the Radiation Therapy Department. The data base contains information on cancer patients and on the results of various types of treatment. The information had been collected by the Department over a 3-year period. The program prints selected patient information as determined by the interrogating radiologist.

7. Application Programs for Public Use

Several new programs were included in the ACME Public Library. These include a routine employing the Cooley-Tukey Fast Fourier Transform Algorithm and AZTEC, a program for reducing a sequence of observation samples to a list of horizontal and inclined straight line segments.

A PL/ACME to PL/I (F-level) translator was written. Most conversions are performed automatically, but manual recoding is still required for conversion of many input and output statements.

Program PLOTPRIN produces plots on the printer or user's terminal. The PL/ACME version of the OPS package is used to generate the plots. Other programs include a data file copying routine, an empty file deletion program, and a program to print an alphabetized listing of a project catalog.

C. System Software Improvements

1. Extended Graphics Support

The Stanford Computation Center Campus Facility OPS (Overall Plotting System) graphics package was adapted to PL/ACME last year. OPS allows the user to plot an entire graph by simple calls for grid, grid labels, titles and plotted data. Any one of ACME's various plotting devices may be specified as the destination of the plot.

Software support was included in the 1800 system for support of the 315C General Purpose Graphics Display Terminal. Both character mode for display of text information and the usual graphics mode (where text may be 'drawn') are provided. In character mode, line and column control is provided. Modes may be intermixed within any PL/ACME program.

The Calcomp plotting package was revised in a very minor manner which surprisingly produced a 20% decrease in execution time. The change was based upon a known FORTRAN deficiency in compiling code for symbolic array subscripts.

2. Additional Realtime Improvements

Four projects are to be cited. Additionally, data rates to and from the 1800/360 were increased by approximately 15% with the installation of the AMPEX bulk core memory. Additional increases in the 1800 data transfer rate do not appear possible due to the limitations of the IBM 1800 hardware.

The 1800 disk management routine was redesigned so that realtime data collected on the disk is not lost as a result of a failure of the 1800 system.

A PL/ACME function EVENT was added to the language syntax. This function allows the user to detect the occurrence of a data transfer into the 360 and to issue a read command only after the transfer has completed. The benefits include simultaneous processing while waiting on a realtime occurrence and the ability of a program to respond dynamically to several realtime input devices. The function has been implemented successfully for both 1800 applications and for the Drug Interaction Project via the PDP-11.

Operator permission to use realtime lines was eliminated. Programmed use of devices routed through the PDP-11 require no operator permission. A PL/ACME function allows the 1800 user to enable himself (the PERMIT18 function). The operator is informed of 1800 status via operator console messages and via the SHOW DSOPEN command. He may disallow further use of realtime lines when data rates for all lines reach the physical maximum.

ACME system control is based upon a two-level priority scheme. The highest level is allocated to the 1800 realtime user. Changes were incorporated so that the duration of time for any realtime user on the high level priority queue is dynamically variable.

3. Improved Text Editing

ACME's text editing package was enhanced by the addition of the LIST and CHANGE commands. LIST outputs lines on the terminal; CHANGE modifies lines of text without the requirement of user verification. In both cases, one may edit according to a specified line range or context criteria. Terminal output may be suppressed completely or limited to text only or line numbers only. A by-product of this project was general improvements to the code for the MODIFY and DELETE commands. A portion of the Text Editor was written in Assembler Language to facilitate rapid execution.

4. Additional Terminal Support

Concomitant with the installation of the Memorex 1270 Terminal Control Unit, software additions recognize a terminal type and invoke the necessary supporting software. 2741 correspondence code terminals are more easily specified at logon time. ASA standard terminals are supported for both display and typewriter devices and from all TCU ports.

5. Satellite Machine Support

Two major efforts for the support of satellite computers are noteworthy.

Stanford Computation Center Engineering Services has completed the design of a satellite computer multiplexor interface to one of our 2701 ports. Supporting software has been implemented for the ACME system and for PDP-11 satellites.

The ACME software resembles the current 1800/PDP-11 support in many ways. The user interface is nearly identical. All communications is asynchronously interrupt driven. Differences in the supporting software do exist, primarily because of protocol destinctions and because of an effort to learn from the 1800/PDP-11 software implementation.

The SM multiplexor software is in the middle stage of debugging. We expect to have the project completed by midsummer.

A program to simulate the PDP-11 is available for batch operation and is in the debugging phase for ACME time-sharing execution. The Simulator executes in single instruction step mode. Diagnostic information is returned after the execution of each instruction of a PDP-11 program. The Simulator provides the debugging capabilities of the PDP-11 front panel as well as the capability to initiate the functions of DEC's ODT debugging package. A core loader and a core dump routine are also provided.

6. LISP Additions

Last summer, we added some 32 mathematical and logical functions to the interactive LISP compiler. This was accomplished by interfacing LISP to the corresponding PL/ACME functions.

A version of LISP for batch execution, identical to the SCC 360/67 LISP, has been mounted on ACME. As of preparation of this report, the LISP user has a limited method for submitting OS JCL and ACME files for overnight batch LISP execution. Further efforts on OS RJE submission from ACME are planned for next year. Upon completion, a batch LISP job may be more conveniently specified and the results more easily retrieved at a terminal.

7. File Support Improvements

Several additions to File System support were implemented in the past year. The primary additions are a data compaction algorithm for reducing disk storage space requirements and several new catalog management functions.

The characteristics of numeric and character-type data collected by a program and subsequently stored on disk indicate that considerable file storage could be saved with some simple data compaction algorithms. A study in February, 1972 of existing numeric data is summarized in Appendix C. Storage savings up to 50% are realizable, depending upon the compaction option's degree of use by the user community. System design has been completed. Implementation will begin soon.

Batch execution of requests to move user files to and from tape and disk was partially automated by the inclusion of public and operator programs for generation of OS job requests. On the overnight operations shift, the operator starts an OS reader task which reads the job requests from the reserved disk data set and sends the jobs into the OS job queue. Two specialized utility routines were written for maintenance of the job request data set.

Further plans for an ACME RJE interface will automate this service completely by eliminating any need for operator intervention. Job requests submitted from a terminal will be routed directly to a spooled job queue.

Other improvements include two PL/ACME functions, BLOCKS and TYPE, for determining assigned disk block space and the storage mode of a file (data or text) respectively, the extension of the PROTECT statement to prevent a DELETE on a file, and the new SAVE FILE command. SAVE is similar to CLOSE in that index and data core buffers are written to disk, but a subsequent OPEN is not required for continued use of a file. SAVE is a guarantee against loss of data in the event of a system crash.

8. Accounting Software

Software accounting changes included modifications for the new charging structure, the addition of time-slices accounting to the system control program, and the inclusion of charges for printing and punching services. Also, disk file accounting was removed from the weekly Analyzer program and a new, high-speed file accounting routine written for rapid collection of file use charges.

9. PL/ACME Compiler Improvements

The addition of Variable Array Allocation to the PL/ACME language extends its flexibility and cost savings features. Previously, allocation of large arrays were under dynamic control, but the size of the array was explicitly declared at compile time. Now, array size definition may be deferred until execution time. Furthermore, array size (and the core requirement of an array) may vary dynamically during a single execution of a PL/ACME program.

10. Deferred Projects

Last year we reported on two system projects whose implementation has since been suspended. The ACME to OS file conversion project was suspended due to some design deficiencies and the lack of staff personnel. A design specification has been completed which builds on the previous effort, but increases the flexibility of the anticipated service. Full implementation is expected in the near future.

Extended logon, wherein a user session is controllable from a device other than one routed through the IBM 2702 (now Memorex 1270) was suspended when unforeseen design problems were encountered in the ACME system. This project, its desirability, and plans for system modifications to accommodate it are further discussed in Section IV.

D. Hardware Changes

1. Ampex Bulk Core

AMPEX bulk core has replaced 2 megabytes of IBM bulk core. The Ampex equipment has a cycle time of 2.5 microseconds versus the 8 microsecond IBM core. Responses of the ACME system improved considerably following the installation in November 1971.

Core timing studies, conducted during installation of the AMPEX core, are reported in Technical Note WCTR (See Appendix B). Execution time of sample PL/ACME programs improved from 18% to 59% with an average improvement of 36.5%.

2. AMPEX Disk Drives

AMPEX DM312 disk drives (17 spindles) replaced the IBM 2314 disk drives in December 1971. The primary improvement here is an average head seek time of 32 milliseconds as opposed to 60 for the IBM drives. The drives were leased as a part of the contract for the AMPEX bulk core.

3. Memorex 1270

Automatic terminal typing and speed recognition became possible when the IBM 2702 transmission Control Unit was replaced with the Memorex 1270 Terminal Control Unit. Devices other than a 2741 terminal or Teletype typewriter are easily supported up to speeds of 1200 bps. Furthermore, TCU ports no longer need be dedicated to a specific terminal type. Any TCU port may recognize and service any terminal, whether typewriter, display, or computer. ACME views this hardware modification as a major marketing and user service attribute. We intend to exploit its potential wherever necessary and possible.

4. Development PDP-11 System

In last year's report, a small machine equipment pool was proposed. A development PDP-11 system has been acquired through purchase on a second-hand basis. This system includes 8k of core, a printer, a card reader, a fixed-head disk, and an expansion box. The system is being shared by a number of ACME users and is also serving as a test vehicle for small machine support development by the ACME staff.

5. Satellite Computer Multiplexor

This is a specialized hardware interface whose purpose is to allow shared access to the ACME system via one of our 2701 TCU parallel data adaptor ports. The multiplexor was especially designed and built by the Stanford Computation Center Engineering Group for the ACME Facility.

The design is such that 16 satellite computers share a single 2701 port on a block-multiplexed basis. One computer controls the communications interface from start to completion of transfer of a data block. At block transfer completion, control of the interface yields to the next computer if necessary. Data rates up to 250 KB can be sustained. Several designed-in safety features insure that neither the multiplexor nor the the satellite computer can disable the ACME system. Rigid adherence to a communications protocol and a set of hardware timeout functions are the primary guarantees.

6. General Purpose Graphics Terminals

Two 315C General Purpose Graphics Terminals were received in May 1971 from Dr. Harold Shipton and made available to users in the fall of 1971. The displays are now in use by the Department of Genetics and by Abraham Silvers of the Department of Medicine.

On April 3, 1972, the Stanford Medical Center hosted a conference on user experience and reaction to the 315C terminal. The conference was initiated by Dr. Shipton and attended by representatives of eight universities. The general impression was that the conference was informative and successful.

An evaluation of Stanford's application of the GPGT is forthcoming to NIH.

7. 2741 Terminal Replacement Study

Several weeks ago a survey was instituted of available CRT and hardcopy terminals. We are especially interested in 30 and 120 cps terminals now supportable by the Memorex 1270 Control Unit. Several demonstration terminals have been tested by the staff. Some are acceptable, others not.

We expect to purchase several representative terminals from this year's grant funds and from requested funds for next year.

Alphanumeric displays have been used during the past year as realtime devices by the Drug Interaction Project. However, the bulk of ACME users have not had access to CRT terminals primarily due to the speed limitation of 15 characters per second. Wider exposure is now possible (and desirable) with the installation of the Memorex unit.

8. Tape Cassette Study

Last year we indicated that we intended to explore the use of tape cassette attachments for storage of user data. A survey was conducted of cassette units currently available. The conclusion was that no unit performed reliably enough to recommend its use as a storage backup medium. Consequently, other alternatives are under consideration.

9. Planned Acquisitions This Year

Funds remaining in the current budget for hardware acquisitions will be used for purchase of three items:

a. A dual DEC tape transport and controller. We wish to provide DEC tape on our front-end PDP-11 as a convenient and inexpensive method of removing user files from disk when the files need not be continuously on-line.

b. One or two 30 character per second thermographic type terminals. Under consideration are the Anderson-Jacobson 630 and the Execuport 300.

c. Additional acoustic couplers and modems for the higher speed terminals and remote user installations.

E. Operations Report

1. System Reliability

The Mean time between failure fell last year primarily because of the higher than normal system instability during the installation of AMPEX equipment. A chart in Appendix D, comcomparing monthly MTBF for the past three years, shows the pattern vividly. The first of the AMPEX core modules was delivered in November; the last of the AMPEX disk drives were installed in January. By the end of February, the new equipment was stabilized and the MTBF rose dramatically.

Nonetheless, the system failure rate for the year from all causes is slightly better than last year's record. This would indicate that failures due to non-hardware system components are rare, and that the ACME system software is extremely stable.

A chart, summarizing MTBF rates in hours for the past three years follows.

MTBF (System Crashes)	FY70	1 FY71	2 FY71	3 FY72
Hardware caused	64.3	246.6	214.8	147.7
All reasons	34.4	84.8	80.7	82.2

1 Projected figures reported in last year's report.

2 Actual MTBF for the entire year of 1971.

3 Projected totals for 1972. Average of MTBF for AUG71-APR72 determined estimates for MAY72-JULY72.

2. Hours Change

ACME service hours were changed to 7:00am-5:30pm and 11:00pm, daily and weekends. The effects of the modification were to delay the late afternoon system programmer block by one-half hour (from 5:00 to 5:30) and to extend the late evening service period by one hour (from 10:00 to 11:00).

3. Utitity Services

Printing and punching services, performed routinely by operations for the benefit of the user community, are now chargeable under the new rate structure. Statistics on quantities of lines printed/cards punched show that the number of printed lines in March, 1972, was 50% greater than the figure for August, 1971. The demand for punching service has remained relatively low. Of the total printing load in the August to March period (3,575 * 1000 lines), fully 87% is rechargeable.

F. Education and Training

1. PL/ACME Classes

During the 12 months ending April 30, 1972, ACME provided formal instruction to 182 persons. Of these, 164 were enrolled in the PL/ACME introductory course and 18 in the advanced programming course. The format of the courses was changed from three to four sessions each lasting one and one-half hours.

A questionnaire was used during the past several months to obtain data on introductory class participants. A total of 49 questionnaires have been collected to date. The limited sample indicates that:

a. Eighteen of the 49 or 37% expressed specific interest in realtime applications.

b. Roughly 50% are staff employees, the remainder are faculty and students.

c. About one-half are from the Medical School, 25% from the Hospital, and 25% from other departments.

d. Fifteen percent report the PL/ACME course was taken for use in a new project.

e. Thirty-five percent have a Ph.D. or M.D.

2. Medical Computing Seminars

A seminar series was organized to encourage the dissemination of information on biomedical computing in the Stanford community. The first seminar included a talk by Dr. James Fries, Department of Immunology, on his Time-Oriented Medical Records project, and a film depicting the patient-oriented medical records system developed by Dr. Larry Weed.

For the second seminar, George Swanson of Anesthesia described his research activity involving studies of the esophagus. Dr. Howard Sussman and his staff presented the new Clinical Laboratory Information System in the third seminar. Approximately fifty people attended each session. ACME will continue to serve as coordinator for this seminar series.

3. Consulting

Last summer, the consultant's office was moved from the ACME office area to a partition in the machine room. The move was designed to permit greater accessability of the consultant to the user community. In January, the systems staff joined the regular consulting staff in manning the consultant's office. Guaranteed consulting hours are 9:30-11:30 and 1:30-3:30 daily. Each systems staff member is assigned one two-hour block weekly.

4. Staff Training

Several members of the staff have or are scheduled to attend IBM and DEC education classes this year. Chargeable classes, covered by the ACME grant are:

Ying Lew:	DEC: PDP-11 School
Charles Granieri:	IBM: TP Systems Control for Programmers
Stu Miller:	IBM: Advanced Coding
Lee Hundley:	IBM: Project Management
Regina Frey:	IBM: Project Management.

IV. PLANNED PROGRAM FOR FY1973

A. Objectives

The upcoming year will be a period of transition. The Medical Center Computing Facilities Planning Committee will define and establish the nature of computing at the Stanford Medical Center. Assuming that the grant proposal for the SUMEX Computer Facility is approved by NIH, we will begin preliminary efforts on system design, equipment specification, and training. Specific actions are necessary for stabilizing the current ACME system and for increasing the level of self-sufficiency of the ACME Facility.

It must be assumed that the ACME system, as currently constituted, will continue to exist after July 31, 1973 until such time as a blend of the SUMEX Grant, Medical Center computing plans, and Stanford-wide computing produces a viable alternative. The trends of use in the past year show that the majority of users depend upon the ACME system as a routine laboratory tool for solution of their own research problems. We expect this dependence upon ACME for service computing to continue.

B. Applications Development

1. Digital Filtering Program

We have contracted with Professor William Gersch of the University of Hawaii for a summer project on development of several digital filtering, spectral analysis, and time series analysis programs. They will be designed for application to to ACME realtime user problems and will be publicly available. The availability of these programs will be an asset to the system, as some of the techniques to be employed have not, to our knowledge, been attempted elsewhere.

2. Installation of Voice Drum

The voice drum will be interfaced to the production PDP-11 system this summer. The initial application of this device will entail retrieval of limited patient data for the Division of Oncology. Residents and others will be able to access limited patient data via touch-tone telephones from throughout the Medical Center or from their homes. This project involving the Oncology Division is in the early planning stage at this time. (See further notes in Hardware and System Software Sections.)

3. Stroke Registry Programs

The Stroke Registry Program began over two years ago, sponsored by the California Regional Medical Program. The goal of the program is to develop a population base for analysis of descriptive parameters of stroke and to produce predictive output for the improvement of care and treatment of patients.

At this time, first year followup data on surviving patients is being collected. A member of the staff will develop programs for entry of followup data and for correlation analysis.

4. Critical Path Analysis

A publicly available computer program for critical path analysis of a class of multi-segment resource scheduling problems is scheduled for implementation soon.

inistration to medical
g resources. The administra-
ct would benefit greatly from

rom the Stanford Linear
e to PL/ACME.

written the well-known
on text data. This program
ort algorithms examined,
ritten for the Public Library.

Center management, from general adm
programs and management of computin
tion of any externally funded proje
such a program.

A FORTRAN program, available f
Accelerator Center, may be adaptabl

5. Fast Sort for Text Data

A member of the ACME staff has
SHELL sort algorithm for operation
will be reviewed, other published s
and a generalized PL/ACME program w

6. Bibliographic Data Entry

A number of our users have developed programs for automation of preprint and bibliographic files. These will be reviewed and a suitable program adapted for public use.

7. Time-Oriented Medical Records Support and Other Patient Data Base Studies

By the fall of 1972, we hope to review all the work performed to date on time-oriented medical records in order to select the optimal file design, the data entry format, and retrievable vocabulary for the near term users. Our goal will be to provide the system tools and the systems or applications programming that will yield generalized programs which can be used by many different departments in the Medical Center. We have found that implementing the system in the Oncology Department required some changes from the programs used for the Immunology Clinic. We have been impressed by physician acceptance of the time-oriented medical record. Please refer to the user project descriptions for Drs. Fries and William for additional explanation of the time-oriented medical record concept.

Additional patient data base studies will be undertaken with the following goals:

a. Obtain as much information as possible concerning new file systems to be supported by IBM and other manufacturers. Review the Stanford SPIRES system as to its applicability.

b. Monitor carefully the problems encountered at Stanford in use of the time-oriented medical records.

c. Through literature, search, and travel remain well informed of work being performed elsewhere.

d. Assign at least one Computer Science department graduate student (research assistant) to the problem of file structure design for patient medical records.

The goal of these studies will be to provide a broad base of information on file system technology and patient data base systems that will be used to guide Stanford's development and implementation of medical information systems.

C. Hardware Acquisitions

Rental and purchase funds are included in the FY73 budget for several additional items of hardware. A discussion of each item follows.

1. Terminals

Several 2741 terminals will be released and funds will be used to acquire two additional high speed hard copy terminals and four CRT terminals. We are especially interested in terminals capable of operating at 1200 baud. The choice will be limited to standard EBCD, Correspondence Code, and ASA terminals, if at all possible.

2. Public Printer/Plotter

The availability of a relatively fast printer/plotter device for general use has been requested by our users. We have been looking at several electrostatic printers, as such a device provides extremely fast and flexible printing and plotting. However, electrostatic devices place a high demand on CPU and channel resources. A further review of available plotters will be conducted before a decision is reached.

3. PDP-11 Equipment

An item is included for purchase of additional core memory for both the development PDP-11 and the front-end PDP-11.

Several additional devices (printer/plotter, DEC tape, voice drum) are to be attached to the front-end PDP-11. Available core will not be adequate to service these devices.

The current 8k of core on the development PDP-11 is minimal for DEC's operating system. Furthermore, several users have been unable to perform some operations due to the core limitation. An additional 8k is required.

4. Ampex Disk Drive

Current 360 disk utilization approaches full capacity. Addition of a new user pack may be necessary unless significant savings result from the new file compaction algorithm.

The disk configuration is eight on one control unit, eight plus spare on the other. On the first control unit, the eighth drive serves as a spare since only fifteen disk packs must be permanently mounted. If we decide to add an additional user pack (always permanently mounted), rental of a second spare drive guarantees better system reliability.

5. Miscellaneous

This category includes interfaces and cabling for the voice drum and additional acoustic couplers and modems (particularly for 1200 baud terminals).

D. System Software

The specific suggestions for system software tasks are derived from four criteria:

1. The software should be stabilized as soon as possible.
2. System documentation must be completed.
3. Additional or improved user services should be aimed toward attracting additional income.
4. All changes in the form of additional features should be disallowed and the system frozen by the end of the grant year.

Three major modifications (points 5, 6, and 7) are in direct conflict with rquirements one and four. However, they are also the primary tasks for achieving requirement three.

1. System Stabilization and Cleanup

The effort here will concentrate on the elimination of known inconsistencies and errors in the system. Wherever easily possible, attempts will be made to reduce the size of the software.

2. Documentation

A considerable documentation effort is planned. The aims are to remove incompleteness and redundancies in the current documentation of the system software. A general paper should be written explaining the system design, the general functional flow, and the interactions of the various components. Also, a comprehensive table of contents and a cross index to each subject category is useful.

Cleanup of documentation and the software will benefit any transfer of the system code to another machine and it will expedit the maintenance of the system by a reduced staff.

3. Support of Additional Hardware

We anticipate attaching a number of new peripheral devices to the system. A list of possibilities is discussed in Section C above.

Additional software will be required in the front-end PDP-11 system for support of the voice drum, DEC tape (purchased from this year's grant), and a printer/plotter. Depending upon the type of printer/plotter selected, we may be able to adapt manufacturer-supplied software.

With the installation of the Memorex 1270 controller, session-controlling devices (terminals) and graphics devices are often synonymous. A few of the planned projects are:

a. Where necessary, add specialized terminal support. An example is the inclusion of the Correspondence Code translation table as developed by the Stanford 360/67 facility for the unique features of the IBM Magnetic Card Selectric Typewriter terminal (MCST). The new TEKTRONIX terminals (4010), if selected, will require some specialized support.

b. Add a few terminal control commands, such as SET UPPER/UPLOW and SHOW CASE for specifying upper and lower case options. Other commands determine the terminal type (ASA or TTY), and suppress or allow transmission of the ACME light box characters.

c. For high-speed displays, incorporate modifications to the LIST command so that output is suspended every N lines. This allows the user to scan a page of lines and use BREAK if he is interested in stopping at that point.

d. Implement page mode output for displays. A full screen of data is displayed directly from the user's in-core array or variables with a single command. The user may then modify the contents of the screen and read it back with another command. Some of the problems in implementation of this capability are identical to those discussed under 'Extended Logon'.

4. Additional Satellite Machine Support

Satellite machine support will focus on tasks essential for a smooth transition to SUMEX and other long range programs expected to succeed ACME. In addition, assistance will be provided to small machine users wishing to connect to the new small machine multiplexor.

5. Batch and OS Services

The provision for a user batch service seems necessary for several reasons:

Current methods for submission of user disk-to-tape jobs and for submission of LISP overnight work are inadequate and operationally difficult to control.

Our present method for providing routine printing and punching services invites some danger to the reliability of the ACME system. Occasional long delays produce poor turn-around time.

A number of jobs now routinely executed from an ACME terminal need not be run interactively. Scheduling these jobs for overnight batch frees both the terminal and the CPU for additional on-line work.

Recent hardware monitor tests indicate that the CPU is busy for 90%-95% of available cycles during peak daytime hours. Also, there is little free core available during the same hours.

Consequently, only a small printing/punching utility region could be supported during the prime shift. However, sufficient core and cycles are available during evening and overnight shifts to accommodate a limited load of user batch work.

Provision for a batch service requires the completion of these tasks:

a. An OS-type task which will convert ACME-type files to OS files and the converse. The design document on this feature has been completed. Both direct access and tape data sets will be supported.

b. Incorporation of the HASP system into the OS supervisor. HASP facilities are preferred over conventional OS services for both better operational control and for its smaller core and disk requirement.

c. Review of the WYLBUR/HASP interface and its adaptation to the ACME system, if possible. Otherwise, the development of a capability to communicate with the HASP in-core reader.

d. Development of a small library of standard OS procedures for routine utility operations (printing, punching, etc.)

e. Adaptation of HASP accounting. Development of a program to merge HASP accounting with time-sharing accounting.

6. PL/ACME Object Modules

The ability to save compiled code on a PL/ACME program and reload it at a later time has been repeatedly requested. Unfortunately, we have avoided the subject primarily because of the lack of a definitive statement as to its impact on the current design of compiled code.

Reloading of compiled code saves user setup time. It also frees CPU cycles now used for recompilation for more productive purposes.

Due to the time constraints of the next year and due to the uncertainties mentioned above, this project is initially planned as a two man-month study and design specification. Actual implementation plans will be deferred until the level of effort is known and until the choice of a computer system is determined.

7. Extended Logon

As the ACME system is currently configured, a user session can be controlled only by a device routed through the Memorex 1270. References to the desirability of expansion to logon services are to be found throughout this report.

Specifically, some of the extensions are:

a. Allow a satellite computer to function as a terminal, invoking programs, etc.

b. Allow our front-end PDP-11 to act as a master terminal, 'logging on' users from devices not necessarily capable of sending and receiving lengthy transactions (such as touch-tone telephones).

c. Provide a master/slave terminal concept, so that one copy of a user program can service multiple requests from multiple, geographically separate, users.

d. Page mode support for CRT's requires extension to the 'one-line-at-a-time' mode of operation.

The precise technique for implementation has not been determined. However, a reorganization of high-level system control functions is absolutely necessary. Expansions to the GET/PUT and READ/WRITE statements of PL/ACME are a possibly simple scheme for user communications.

We feel that this is the most valuable of all suggestions for additions to the ACME system. The considerable design effort and its impact upon the total structure of the system software are more than justifiable.

8. Miscellaneous

This category contains a number of small projects, none of which may produce any significant increase in system usage, but all of which provide gratifying additions to the current level of service. Compared to the level of effort anticipated for implementation of other proposals in this section, these projects require very minor manpower expenditures.

a. A method whereby a user may determine his aggregate monthly charges from his terminal (SHOW CHARGES command).

b. Extensions to the Text Editor to allow relocation or duplication of lines of text within a data set (MOVE/COPY commands).

c. Addition of the UNPROTECT command to complement the PROTECT command. This command is necessary if a user wishes to delete or maintain an existing protected file.

d. A technique is needed whereby a user can guarantee sufficient disk file space for writing data to his data set. A simple implementation is to provide an option wherein the user specifies the number of disk blocks required at OPEN time. The blocks are held in reserve for him (assuming they are available) until either they are consumed or the file is closed.

V. ADMINISTRATIVE ORGANIZATION

Stanford University has an Associate Provost for Computing and reports directly to the Provost and Academic Vice President. The Provost for Computing and heads the operation of three major facilities: Campus facility, ACME facility, and SLAC computing facility. The current SCC director, Charles Dickens, has made a number of organizational and procedural changes during the past year in an effort to find an optimal organization for Stanford's system programming efforts. One finding was that organizational rather than functional lines seem to be the most appropriate in the Stanford setting. For six months we had a single systems group manager for all three facilities - SLAC, Campus, and ACME. Some benefits of the trial period were the creation of a better reporting system, cross-fertilization of ideas, and much more interaction among the systems programmers. Some of the disadvantages were a longer communications chain, travel time between facilities, and some loss of control by facility directors. The operations managers of the three facilities were also brought together in one functional arm of the organization. Cross-facility training among operations was partially completed. Reporting schemes were unified, and an exchange of ideas was accomplished. Today, the functional organizations exist for purposes of communication and coordination. Formal lines of authority, however, have been returned to individual facility directors.

We have had a number of meetings in the past year with the Hospital Data Processing facility director and his staff. A new era of cooperation and communication between Hospital Data Processing and ACME has arrived.

The personnel currently on the ACME payroll, their job function, and percent of full time equivalents are listed below:

CURRENT ACME PERSONNEL

NAME	%FTE	JOB TITLE
Jamtgaard, R	100	Director
Wiederhold, G	20	Consultant
Kindfleisch, T.	50	Systems Analyst
Hundley, L.	100	Systems Programmer
Frey, R.	100	Systems Programmer
Granieri, C.	100	Systems Programmer
Lew, Y.	100	Systems Programmer
Miller, S.	100	Systems Programmer
Briggs, R.	20	Systems Programmer
Stainton, R.	100	Systems Programmer
Bassett, R.	100	Scientific Programmer
Crouse, L.	100	Scientific Programmer
Whitner, J.	100	Scientific Programmer
Aranda, M.	100	Secretary
Baxter, E.	100	Administrative Asst.
Class, C.	100	Operations Manager
Cower, R.	100	Computer Operator
Sutter, J.	80	Computer Operator
Matous, J.	100	Computer Operator
Mieman, J.	60	Computer Operator
Cannon, D.	50	Dispatcher
Total FTE	17.9	

VI. BUDGET

A. Resource Expenditures

SUMMARY

		Total Resource Expenditures		
		Actual Previous Budget Period	Current Budget Period	Estimated Next Budget Period
1.	Personnel:			
	a. Salaries & Wages	239,329	248,690	277,162
	b. Staff Benefits	32,851	37,505	44,231
	Subtotal	272,180	286,195	321,393
2.	Consultant Services	912	1,000	1,000
3.	Equipment			
	a. Main Resource-Rented	384,542	389,458	390,596
	b. Main Resource-Purchased	40,848	54,479	50,000
	c. Supporting Equipment	1,951	1,260	1,260
	d. Equipment Maintenance	6,145	14,500	18,805
	Subtotal	433,486	459,697	460,661
4.	Supplies	15,873	9,200	9,700
5.	Travel	3,047	4,000	4,000
6.	Engineering Services	11,818	30,000	31,500
7.	Publication Costs	3,031	2,000	2,500
8.	Other			
	a. Computer Services (1)	8,272	3,100	7,900
	b. Other	9,531	10,100	11,200
	Subtotal	17,803	13,200	19,100
9.	Subtotal - Direct Costs	758,150	805,292	849,854
10.	Indirect Costs	141,205	76,600	21,771
11.	Total Costs	899,355	881,892	871,625 (2)

(1) Includes education courses

(2) Assumes $443,976 exempt equipment costs and user income of $360,000.

B. Justification for FY1973 Budget

Fiscal year 1973 will be the final year for the ACME Grant. The gross operating costs will be slightly higher than fiscal year 1972, primarily due to salary increases, some incremental equipment rent and maintenance, and some additional programming help for users. The emphasis in this final year will be one of pulling loose ends together and preparing for a transition to alternate hardware for research and service computing. In addition, strong effort will be made to improve the income posture of the facility so that it can survive in future years without the financial guarantees provided under the ACME Grant.

The budget for fiscal year 1973 assumes that the staff level achieved in fiscal year 1972 will be retained. The facility is currently recruiting a replacement for Gio Wiederhold who has had primary responsibility for liaison with users and supervision of the consultants. Gio Wiederhold assumed new responsibilities in the Hospital Data Processing Facility in March, 1972. ACME continues to pay a fraction of his salary for consulting on system problems and planning.

An average salary increase of 5% has been included in the budget for fiscal year 1973.

Equipment rental costs have been budgeted at the current rental rates. The overall equipment rental budget is slightly higher than fiscal year 1972 due to the installation of Ampex core. Similarly, the hardware maintenance budget is up slightly due to acquisition of terminals and aging of interface hardware built during the past six years, and maintenance of the small machine equipment pool acquired over the past 18 months.

Some miscellaneous budget elements include funds for training of staff on the PDP-10, acquisition of some terminal service on PDP-10's run by other institutions, and some additional communications costs associated with the move to multiple speed terminal support made in April, 1972.

Capital equipment requested for the new budget period is as follows:

1)	Four CRT terminals	12,600
2)	Electrostatic Printer/Plotter, or expansion of small machine equipment pool	22,000
3)	8K of core for development PDP-11	5,700
4)	4K of core for production PDP-11	3,300
5)	Two 30 character per second typewriter terminals	5,000
6)	Acoustic couplers, modems, etc.	1,400
	TOTAL	$50,000

The CRT's and 30 character per second typewriter terminal will replace IBM 2741 terminals which have been rented by the facility in the past. The terminals are less expensive and will provide faster output and a savings of programmer time. The printer/plotter to be acquired has not been selected yet. This item is incorporated in the budget because graphic support continues to attract more users. At the present time the ACME facility has no plotter to support its users. Three user groups have plotters attached to ACME and they find the provision of service to miscellaneous users more than a trivial nuisance. Provision of good interactive graphics support on the ACME system will demand that the facility offer plotting to its users. Another problem which we have had is the slow turnaround on print jobs caused by the speed of our printer and the system degradation caused by use of the printer while PL/ACME is running. This latter problem is induced by IBM hardware and software constraints which cannot be fixed without a very sizable expenditure of effort.

The core for the Development PDP-11 and Production PDP-11 systems will permit use of the DEC Fortran compiler on the development system and will remove the limitation which has hampered the efforts of several development groups. The added core for the production PDP-11 will be needed only if several additional user devices or services are interfaced through the PDP-11. We have barely enough core to mount the voice drum at the present time. We assume that additional special devices will be needed.

Funds for acoustic couplers modems, etc., will be needed to effectively use the new terminals from remote locations. Also, a number of medical school groups are being moved to space adjacent to but outside of the current Medical Center buildings. For such users, telephone service for terminals is a must. This requires expansion of the communication equipment available. Users pay for their own terminals and acoustic couplers but the facility helps to respond to their temporary requirements or new requirements pending delivery of new equipment.

C. Expenditure Details

DIRECT COSTS ONLY

	August 1, 1971-July 31, 1972	August 1, 1972-July 31, 1973
1. Personnel		
Director's Office	32,929	23,582
Systems Analysis	4,633	10,600
Systems Programmers	94,306	97,960
Applications Programmers	39,042	63,470
Research Assistants	9,852	7,150
Operations	52,430	58,680
Secretarial & Administrative	15,498	15,720
Subtotal, Salaries	248,690	277,162
Staff Benefits	37,505	44,231
TOTAL PERSONNEL	286,195	321,393
2. Consultant Services	1,000	1,000

C. Expenditure Details

DIRECT COSTS ONLY

			August 1, 1971-July 31, 1972		August 1, 1972-July 31, 1973
3. Equipment					
Major Equipment					
1052	Console Typewriter		635		635
1403	Printer 600 LPM		8,397		8,397
2050	Additional CPU (F)		99,955		101,817
2314 #1	Dir. Acess Storage		21,466		-----
2314 #2	Dir. Acess Storage		19,988		-----
2361	Core Storage		27,291		-----
2401	Mag. Tape Unit		3,377		3,377
2403	Mag. Tape Unit Control		8,971		8,971
2540	Card Reader Punch		6,947		7,157
2701	Data Adapter Unit		10,561		10,728
2702	Transmission Control		16,834		-----
2821	Control Unit		10,937		10,937
	Ampex DC 314		20,068		36,304
	Ampex DC 314		22,243		36,304
	Ampex ECM-50		77,949		119,922
	Memorex 1270		-----		16,248
Subtotal			355,619		360,842
Disk Packs (IBM 2316/3)		(25)	2,114	(25)	2,100
Terminals (2741)		(11)	11,763	(4)	4,109
IBM 1800 add. units					
1442			2,638		2,671
1826			7,691		7,691
1856			1,701		1,701
Subtotal, 1800			12,030		12,063
Unit Record 029			1,192		1,259
TOTAL, RENTALS			382,718		380,373

C. Expenditure Details

DIRECT COSTS ONLY

	August 1, 1971-July 31, 1972	August 1, 1972-July 31, 1973
Purchased Equipment		
RPQ's for Beehive Terminals	381	
PDP-11 System	38,466	
DEC Dual Tape System	8,700	
1200 Baud Modems (2+ Power Supply)	750	
Computer Terminals (2)	6,182	
Four CRT Terminals		12,600
Electrostatic Printer/Plotter, or expansion of small machine equipment pool		22,000
8K of core for development PDP-11		5,700
4K of core for production PDP-11		3,300
Two 30 character per second typewriter terminals		5,000
Acoustic couplers, modems, etc.		1,400
	54,479	50,000
Data Set and Line Rentals	8,000	8,400
Maintenance (Under outside contract)	14,500	14,805
Total Equipment	405,218	403,578

C. Expenditure Details

DIRECT COSTS ONLY

		August 1, 1971-July 31, 1972	August 1, 1972-July 31, 1973
4.	Consumable Supplies		
	Office	3,700	3,700
	Computer	5,500	6,000
	Subtotal, Consumable Supplies	9,200	9,700
5.	Travel		
	Frey -U. of Missouri Comp. Ctr., 8/6/71		
	-SHARE, New York, 8/9-12		
	-Automated Health Sys., Wakefield, Mass., 8/13	777	
	Nozaki -WESCON, S.F., 8/25	9	
	Wiederhold-SIGPLAN Symp., Purdue Univ., 10/24-26	359	
	Jamtgaard -MUMPS Sys., Boston Gen. Hosp., 11/28-30	426	
	Jamtgaard -Conference, S.F., 1/19-1/21/72	78	
	Wiederhold-Conference, S.F., 1/19-21	78	
	Wiederhold-Conference, Washington, D.C., 1/28-29	364	
	Granieri -SHARE, S.F., 3/6-10	20	
	Wiederhold-SHARE, S.F., 3/6-10	74	
	Granieri -IBM Class, S.F., 4/12-14	33	
	Class -SJCC, Atlantic City & DEC, Boston 5/15-18	525	
	All Other Travel	1,257	
	Subtotal, Travel	4,000	4,000
6.	Engineering Services	30,000	31,500
7.	Publication Costs	2,000	2,500
8.	Computer Services		
	360/67	2,500	2,500
	PDP-10 and Line Charges	----	3,000
	Staff Training	600	2,400
	Subtotal, Computer Services	3,100	7,900

C. Expenditure Details

DIRECT COSTS ONLY

	August 1, 1971-July 31, 1972	August 1, 1972-July 31, 1973
9. Other Expenditures		
Audio-Visual Presentation	----	700
Books and Periodicals	200	200
Postage and Freight	2,000	2,000
Telephone	7,000	7,000
Physical Plant	100	300
Technical Services	800	1,000
Subtotal, Other	10,100	11,200
GRAND TOTAL -- DIRECT COSTS	805,292	849,854

D. Summary of Resource Funding

	BUDGET PERIODS		
	Actual Previous Budget Period	Current Budget Period	Estimated Next Budget Period
Source of Funds			
Computer Equipment - Service	170,596	270,000	360,000
Biotech. Resources Branch Support			
Amount of Current Award:			
Line (5) of Award Statement	675,747	573,755	511,625
Adjustment from Prior Periods:			
1. Line (4) of Current Award	76,459	27,275	
	<27,275>		
2. Balance of 270 x/y Proceeds		5,292	
Total BR Support	724,931	606,322	511,625
TOTAL FUNDING	895,527	876,322	871,625

E. Resource Equipment List

RENTAL EQUIPMENT

360/50 Configuration

TYPE-SERIAL	DESCRIPTION	RENTAL START DATE	MONTHLY RATE	E/A%	EDUCATIONAL ALLOWANCE	TAX	NET RENTAL
IBM:							
1052-50618	Console Typewriter	12-13-66	63.00	20	12.60	2.52	52.92
1403-14708	Printer 600 LPM	"	833.00	20	166.60	33.32	699.72
2050-11047	Additional CPU (F)	"	2,073.00	25	518.25	77.74	1,632.49
2050-11047	CPU	"	10,040.00	35	3,514.00	326.30	6,852.30
2401-10877	Mag. Tape Unit	"	335.00	20	67.00	13.40	281.40
2403-70738	Mag. Tape Unit Control	"	890.00	20	178.00	35.60	747.60
2540-12531	Card Reader Punch	"	710.00	20	142.00	28.40	596.40
2701-11144	Data Adapter Unit	"	1,025.00	20	205.00	41.00	861.00
2701-11144	Data Adapter Unit		35.00	10	3.50	1.58	33.08
2702-20185	Transmission Control	"	1,670.00	20	334.00	66.80	1,402.80
2821-12464	Control Unit	"	1,085.00	20	217.00	43.40	911.40
AMPEX:							
DC 314-034	Dir. Acess. Stge.	12-20-71	2,907.00	--	------	118.35	3,025.35
DC 314-037	Dir. Acess. Stge.	1-13-72	2,907.00	--	------	118.35	3,025.35
ECM 50-1222	Core Storage	12 -8-71	9,545.00	--	------	448.50	9,993.50
360/50 Configuration Total			34,118.00		5,357.95	1,355.26	30,115.31

E. Resource Equipment List

RENTAL EQUIPMENT (Cont.)

Supporting Equipment Rentals

TYPE-SERIAL	DESCRIPTION	RENTAL START DATE	MONTHLY RATE		E/A%	EDUCATIONAL ALLOWANCE	TAX	NET RENTAL
25 units 911	Disk Pack (3M)	5-17-71	(@ 7.88)	197.00	--	------	9.85	206.85
6 units 2741	Communication Terminal	various	(@100.50)	603.00	20	120.60	24.12	506.52
5 units 2741	Communication Terminal	various	(@105.50)	527.50	20	105.50	21.10	443.10
1800 Rental Equipment								
1826-10152	Data Adapter Unit	9-22-66		763.00	20	152.60	30.52	640.92
1442-70295	Card Read Punch	"		265.00	20	53.00	10.60	222.60
1856-10607	Analog Output Terminal	6-24-70		150.00	10	15.00	6.75	141.75
Other Rented Equipment								
Card Punch	IBM (Model 029/P4202)	9-21-70		111.00	10	11.10	5.00	104.90

E. Resource Equipment List

PURCHASED EQUIPMENT

Period Covered -- 8/1/67-4/30/72

DESCRIPTION/IDENTIFICATION	MANUFACTURER	MODEL NO.	PURCHASE PRICE	SOURCE OF FUNDS
1800 System				Genetics I.R.L.
Process Controller	IBM	1801		
Printer Keyboard	"	1816		
Enclosure	"	1828		
Analog Input Terminal	"	1851	2,908.00	
Digital Display	ACME		(1)	SRR
Oscilloscope	Hewlett-Packard		1,500.00	Macy Grant
Pulse Generator	E.H. Research Labs	139B	1,275.00	Macy Grant
Conversion 1801	IBM	2B	18,753.00	
PDP-11 System	Digital Equipment	PDP-11	17,891.00	
Oscilloscope	Tektronix	547	3,253.00	
Printer	Litton Industries	30	4,053.00	
Module/Packs	Prentice	800/LDA-1	2,972.00	
Oscillator/Generator	Wavetek	130	309.00	
Couplers (2)	Prentice	D22	939.00	
Module	Prentice	LDA 1	383.00	
Cabinet	Prentice		4,182.00	
Disk Drive System	Digital Equipment	RK11 CA/RK03AA	15,332.00	
Beehive Displays (3)	Beehive	Model 3	7,668.00	
Sampling Unit	Tektronix	Type 152	1,767.00	
PDP-11 System	Digital Equipment	PDP-11	38,446.00	

F. Income Projection:

A revised rate structure was implemented effective April 16, 1972. In general, rates for use of ACME were increased by 25% to 30%. Some users computing bills were doubled as a result of the new increase. Actual income for the month ending May 15, 1972 amounted to $31,500. Some users will reduce their utilization due to the higher rates. A conservative estimate of income for fiscal year 1973 is $360,000. This figure does not include the terminal service fees which cover terminal rent plus other services to the ACME user community which could not be covered by the current funding level of the ACME grant. Some major users of the current system will be transferring loads to dedicated small computer systems in the next 12-month period. One such user is Dr. Stanley Cohen whose Drug Interaction Program should be running on a dedicated PDP-11 by early 1973. Another such user is Dr. Howard Sussman in the Clinical Laboratory; programs are being written now for use of the newly acquired Sigma 3 by the Clinical Laboratory. Both Drs. Cohen and Sussman will continue to make some use of ACME for data analysis but the income from these two sources will be much reduced over current levels. On the next page you will see a table which shows the monthly income collected by ACME for the past nine months. Based upon this experience and the estimated impact of the higher rates, it is felt that the $360,000 is a reasonable estimate of next fiscal year's income from computer service fees.

ACME INCOME

April 17, 1971 to April 16, 1972

360/50 Income From Chargeable Users	May	June	July	August	Sep	Oct	Nov	Dec	Jan	Feb	March	April	Total
1 - Realtime, sponsored research	$ 2,577	$ 2,372	$ 3,608	$ 4,500	$ 5,812	$ 5,550	$ 4,536	$ 5,346	$ 5,576	$ 6,203	$ 6,200	$ 6,578	$ 58,858
2 - Non-realtime, sponsored research	6,530	9,487	7,357	9,443	9,488	10,003	8,458	9,901	8,725	13,000	18,166	14,630	125,188
3 - Non-Stanford, medical	555	235	359	248	370	206	317	254	409	234	1,435	3,090	7,712
8 - Hospital Data Processing	2,286	2,634	1,260	-0-	-0-	-0-	-0-	-0-	-0-	-0-	1	11	6,192
9 - Stanford, non-medical	3,349	3,821	2,031	2,997	1,275	3,049	1,461	824	496	486	228	1,052	21,069
16 - Combination Core Research and Application	-0-	-0-	-0-	-0-	-0-	-0-	181	966	2,642	2,210	2,830	2,600	11,429
MONTHLY SUB-TOTALS	$15,297	$18,549	$14,615	$17,188	$16,945	$18,808	$14,953	$17,291	$17,848	$22,133	$28,860	$27,961	$230,448
Income from Terminal and Misc Charges*	$ 8,323	$ 8,625	$ 8,315	$ 9,053	$ 8,740	$10,393	$ 9,758	$10,845	$10,145	$ 9,000	$ 9,313	$ 9,225	$111,735
MONTHLY TOTALS	$23,620	$27,174	$22,930	$26,241	$25,685	$29,201	$24,711	$28,136	$27,993	$31,133	$38,173	$37,186	$342,183

*This income is not associated with the ACME Grant. It is an offset to cost incurred by the University for terminal rental, engineering services, and other miscellaneous services provided to the ACME community.

VII. PROJECT DESCRIPTIONS

CORE RESEARCH PROJECT DESCRIPTIONS

Staff

Core research and development projects carried on by the ACME staff during Fiscal 1972 have already been discussed in previous sections of this report.

Principal Investigator

Joshua Lederberg maintains one account for the purpose of system development and testing and another as a utility file for demonstration programs. These projects, PILOT1 and PILOT2, are listed in Category 6 of the Summary of Computer Resource Usage.

Users

During portions of Fiscal 1972, two user projects had core research status: DENDRAL and the Drug Interaction Project. Since both began to be charged for their usage during Fiscal 1972, they are listed below as a combination of core and collaborative research.

CORE AND COLLABORATIVE RESEARCH PROJECT DESCRIPTIONS

Investigator: Edward Feigenbaum, Joshua Lederberg, and Carl Djerassi.
Dept. of Chemistry, Computer Science, and Genetics
Project Began 1970

Project: DENDRAL Realtime
Chargeable use began May 1971

The DENDRAL project involves collaboration between the Instrumentation Research Laboratory operating under NASA grant NGR-05-020-004, investigators operating under NIH grant RR 00612-02, and ACME.

The emphasis of the DENDRAL-ACME efforts is computer science, while that of IRL-ACME endeavors is data acquisition and computer-instrument control.

The DENDRAL project aims at emulating in a computer program the inductive behavior of the scientist in an important but sharply limited area of science: organic chemistry. Most of the work is addressed to the following problem: given the data of the mass spectrum of an unknown compound, infer a workable number of plausible solutions, that is, a small list of candidate molecular structures. In order to complete the task, the DENDRAL program then deduces the mass spectrum predicted by the theory of mass spectrometry for each of the candidates and selects the most productive hypothesis, i.e., the structure whose predicted spectrum most closely matches the data.

Core and Collaborative Research Project Descriptions (cont'd.)

The project has designed, engineered, and demonstrated a computer program that manifests many aspects of human problem solving techniques. It also works faster than human intelligence in solving problems chosen from an appropriately limited domain of types of compounds, as illustrated in the cited publications.

Some of the essential features of the DENDRAL program include:

> Conceptualizing organic chemistry in terms of topological graph theory, i.e., a general theory of ways of combining atoms.
>
> Embodying this approach in an exhaustive HYPOTHESIS GENERATOR. This is a program which is capable, in principle, of "imagining" every conceivable molecular structure.
>
> Organizing the GENERATOR so that it avoids duplication and irrelevancy, and moves from structure to structure in an orderly and predictable way.

The key concept is that induction becomes a process of efficient selection from the domain of all possible structures. Heuristic search and evaluation are used to implement this "efficient selection."

Most of the ingenuity in the program is devoted to heuristic modifications of the GENERATOR. Some of these modifications result in early pruning of unproductive or implausible branches of the search tree. Other modifications require that the program consult the data for cues (pattern analysis) that can be used by the GENERATOR as a plan for a more effective order of priorities during hypothesis generation. The program incorporates a memory of solved sub-problems that can be consulted to look up a result rather than compute it over and over again. The program is aimed at facilitating the entry of new ideas by the chemist when discrepancies are perceived between the actual functioning of the program and his expectation of it.

The DENDRAL research effort has continued to develop along several dimensions during Fiscal 1972. The mass spectra of some previously uninvestigated compounds were recorded. The computer program has been extended to analyze the mass spectra of a more complex class of compounds, using new kinds of data. The artificial intelligence work on theory formation and program generality has also progressed.

Many mass spectra were taken to gather more data for the DENDRAL program. The analysis of the mass spectra of a variety of functional groups provided general mass spectrometry rules for the computer program. The spectra of many estrogenic steroids were taken to elucidate the mass spectrometry of this class of steroids and to provide data for a problem area new to DENDRAL.

The estrogenic steroid problem is new in several respects:

(1) in working with steroids, the program deals with much more complex molecules than ever before;
(2) the computer program uses element maps from high resolution data to resolve ambiguities; and

Core and Collaborative Research Project Descriptions (cont'd.)

(3) The program uses metastable peaks to determine parent-daughter relationships between ions and thus to distinguish molecular ions and their primary fragments.

Programming for the analysis of spectra has been completed. The program and results are described in a forthcoming article:

Smith, D.H., et al., "Applications of Artificial Intelligence for Chemical Inference:VIII: An Approach to the Computer Interpretation of the High Resolution Mass Spectra of Complex Molecules. Structure Elucidation of Estrogenic Steroids," Journal of American Chemical Society, in press.

Analysis of the mass spectra of pregnanes will be the next task for the computer program. Work is under way to collect the data from several pregnane samples and to allow the program to use a less well-defined theory for this class than for estrogens.

The artificial intelligence interests of the DENDRAL groups are reflected in work in program generality, partly described in reference (A), and in the program called meta-DENDRAL described in reference (C), which will infer mass spectrometry rules from collections of data. Parts of the meta-DENDRAL program have been written which codify observations about mass spectrometry, and work has started on the succeeding phase of the program which will generalize these observations into tentative rules.

A. Feigenbaum, E.A., Buchanan, B.G., and Lederberg, J. "On Generality and Problem Solving: A Case Study Using the DENDRAL Program", in Machine Intelligence 6, B. Meltzer and D. Michie (eds), Edinburgh University Press, 1971.

B. Buchanan, B.G., and Lederberg, J. "The Heuristic DENDRAL Program for Explaining Empirical Data", presented at the 1971 Congress of the International Federation of Information Processing Society (August, 1971) and published by North Holland Publishing Co.

C. Buchanan, B.G., Feigenbaum, E.A., and Lederberg, J. "Beyond Heuristic DENDRAL", presented at the International Joint Conference on Artificial Intelligence (September, 1971) and published in the Proceedings.

This system plans to incorporate a high degree of computer control. The goal of the instrumentation project will be to combine the analysis of the DENDRAL computer program with the data acquisition and control capability of the computer. It is planned to do a fast preliminary data acquisition, let the DENDRAL program determine what additional data and data mode is desirable, have the computer control the instrument mode and data scan, and return the pertinent data to the DENDRAL program. Further iterations of this cycle can be repeated as long as the sample persists.

A GLC (gas chromatograph) has been connected to one inlet of the mass spectrometer. The persistence of a given sample is determined by the duration of the GLC peak, a few seconds to half a minute. We have the type of mass spectrometer which usefully takes data in many modes: low, high, ultra-high, resolution and meta stables, high or low ionization potential, etc. It cannot

Core and Collaborative Research Project Descriptions (cont'd.)

acquire all this data in the time span allowed by a single GLC peak. Hence it is desirable that the computer determine, during the limited sampling time, the most useful mode of operation, and then implement this optimum mode.

Dispersed Computer for Instrumentation

During Fiscal 1972, support was given to the development of the "HIQ" remote smart terminal. This was in cooperation with Professor Melvin Schwartz of the Physics Department, with joint NASA support and Air Force support under contract AF F 44620 67C 0070.

This cooperation did develop a unique Direct Memory Access unit for the PDP-11. This portion of the project is concluded. The experience and concepts of that joint effort are now integrated with the realization and future planning of the instrumentation for the DENDRAL project.

This PDP-11 is now being used as a satellite computer to the IBM 360/50 in the data acquisition from the mass spectrometers. As such it is used to preprocess data streams from the mass spectrometers.

The general pattern for system development is to use the larger resources of the ACME 360/50 to develop algorithms. Program techniques may be tried and proved either on real data streams or on files of data from prior instrument runs. After an algorithm has been thus proven, it can be encoded into the less flexible local computer code.

This experience and experiments with this master satellite system are proving invaluable to the economical and adequate selection of the next generation of DENDRAL requirements. (Considerations for this next generation have ranged from a re-dedication of the present hardware to an all new system with a new master and satellite chains of small computers. No firm decision has yet been made.)

In the Summary of Computer Resource Usage, DENDRAL usage is listed under the following names and projects.

Bob Berns	LISP
Larry Hjelmeland	DENDRAL
Walter Reynolds	DENDRAL
	DREAMS
Tom Rindfleisch	DENDRAL
Robert Ross	CHEM
	DENDRAL
Mark Stefik	DENDRAL
Robert Stillman	DENDRAL
	DREAMS

The following two pages list some of the publications which have resulted from the DENDRAL research project.

REFERENCES

1. For pertinent reviews see: C. G. Hammar, B. Holmstedt, J. E. Lindgren and R. Tham, Advan. Pharma Col. Chemother., 7, 53, (1969); J. A. Vollmin and M. Muller, Enzymol. Biol. Clin., 10 , 458 (1969)

2. J. R. Althans, K. Biemann, J. Biller, P. F. Donaghue, D. A. Evans, H. J. Forster, H. S. Hertz, C. E. Hignite, R. C. Murphy, G. Petrie and V. Reinhold, Experientia, 26, 714 (1970).

3. H. Fales, G. Milne and N. Law, reported in Medical World News, February 19, 1971.

4. E. Jellum, O. Stokke and L. Eldjarn, The Scandinavian Journal of Clinical and Laboratory Investigation, 27, 273 (1971).

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7a. Applications of Artificial Intelligence for Chemical Inference. I. The Number of Possible Organic Compounds: Acyclic Structures Containing C, H, O and N.
J. Am. Chem. Soc., 91, 2973 (1969)
By J. Lederberg, G. L. Sutherland, B. G. Buchanan, E. A. Feigenbaum, A. V. Robertson, A. M. Duffield and C. Djerassi.

7b. Applications of Artificial Intelligence for Chemical Inference. II. Interpretation of Low Resolution Mas Spectra of Ketones
J. Am. Chem. Soc., 91, 2977 (1969)
By A. M. Duffield, A.V. Robertson, C. Djerassi, B. G. Buchanan, G. L. Sutherland, E. A. Feigenbaum and J. Lederberg

7c. Applications of ARtificial Intelligence for Chemical Inference. III. Aliphatic Ethers Diagnosed by Their Low Resolution Mass Spectra and NMR Data.
J. Am. Chem. Soc., 91, 7440 (1969)
By G. Schroll, A. M. Duffield, C. Djerassi, B. G. Buchanan, G. L. Sutherland, E. A. Feigenbaum and J. Lederberg

7d. Applications of Artificial Intelligence for Chemical Inference. IV. Saturated Amines Diagnosed by Their Low Resolution Mass Spectra and Nuclear Magnetic Resonance Spectra.
J. Am. Chem. Soc., 92, 6831 (1970)
By A. Buchs, A. M. Duffield, G. Schroll, C. Djerassi, A. B. Delfino, B. G. Buchanan, G. L. Sutherland, E. A. Feigenbaum and J. Lederberg

7e. Applications of Artificial Intelligence for Chemical Inference. V. An Approach to the Computer Generation of Cyclic Structures. Differentiation between all the Possible Isomeric Ketones of Composition $C_6H_{10}O$.

Org. Mass Spectr., 4, 493 (1970)
By Y. M. Sheikh, A. Buchs, A. B. Delfino, G. Schroll, A. M. Duffield, C. Djerassi, B. G. Buchanan, G. L. Sutherland, E. A. Feigenbaum and J. Lederberg

7f. Applications of Artificial Intelligence for Chemical Inference. VI. An Approach to a General Method of Interpreting Low Resolution Mass Spectra with a Computer.
Helv. Chim. Acta., 53, 1394 (1970)
By A. Buchs, A. B. Delfino, A. M. Duffield, C. Djerassi, B. G. Buchanan, E. A. Feigenbaum and J. Lederberg

7g. The Application of Artificial Intelligence in the Interpretation of Low Resolution Mass Spectra.
Advances in Mass Spectrometry, 5, 314, (1970)
By A. Buchs, A. B. Delfino, C. Djerassi, A. M. Duffield, B. G. Buchanan, E. A. Feigenbaum, J. Lederberg, G. Schroll and G. L. Sutherland.

7h. Applications of Artificial Intelligence forChemical Inference. VIII. An Approach to the Computer Interpretation of the High Resolution Mass Spectra of Complex Molecules. Structure Elucidation of Estrogenic Steroids.
J. Amer. Chem. Soc.,
By D. H. Smith, B. G. Buchanan, R. S. Englemore, A. M. Duffield, A. Yeo, E. A. Feigenbaum, J. Lederberg and C. Djerassi

7i. An Application of Artificial Intelligence to the Interpretation of Mass Spectrometry.
By B. G. Buchanan, A. M. Duffield and A. V. Robertson,
Mass Spectrometry, B. W. G. Milne, Editor, John Wiley and Sons, New York, 1971. pp. 121-178.

8. D. H. Smith, A. M. Duffield - d C. Djerassi, Org. Mass Spectrom., Submitted for publication.

9. Anal. Chem., 42, 1122 (1970); W. E. Reynolds, V. A. Bacon, J. C. Bridges, T. C. Cobum, B. Halpern, J. Lederberg, E. Levinthal, E. C. Steed, and R. B. Tucker.

Core and Collaborative Research Project Descriptions (cont'd.)

Investigator: Stan Cohen
Dept. of Medicine, Div. of Clinical Pharmacology
Project Began October 1969

Project: SNCOHEN. DRUGALRT
Non-Realtime
Chargeable Use Began December 1971

The project involves the establishment of a computer-based program aimed at preventing undesirable drug interactions and reducing drug toxicity at the Stanford University Medical Center. A data bank dealing with drug interactions of clinical significance will be compiled utilizing already available information present in the pharmacological literature. When prescriptions are filled by the Stanford pharmacists, the pharmacists will type the name of the drug and the dosage regimen into a terminal located in the Hospital pharmacy. When a new drug added to a patient's regimen interacts with any one of the several drugs the patient may already be receiving, the computer will print out an appropriate drug interaction alert accompanied by a literature reference, which will then be sent to the nursing unit by the pharmacist--together with the drug. Prior to administering a drug accompanied by such an "alert", the nurse will contact the physician in charge, who will retain the prerogative of deciding whether or not the drug should be administered. This program will provide considerable teaching benefits to students and house staff, in addition to providing benefits of major importance to patient care. In addition, it will be possible to assess the impact of providing physicians with drug interaction information, and also to learn in a prospective way about the clinical consequences of drug interactions.

Initial operation of the system began in September 1971. Since it was anticipated that production of drug interaction warnings would influence the prescription writing habits of physicians, it was desirable to obtain baseline information on drug use, duration of hospitalization and other parameters in various diseases at Stanford University prior to generation of interaction reports. Moreover, in the initial stages of the project, it was desirable to evaluate the ability of the pharmacist to rapidly enter the additional prescription information the system requires without disrupting normal pharmacy routines, and to determine whether an on-line interactive video display unit and label printing program would function effectively in a busy in-patient hospital pharmacy. At the present time, accumulation of baseline information on drug utilization is continuing, and routine interaction reports are not yet being issued.

In the future, it is anticipated that the program will be extended to other hospitals, and a modified version is currently under development that will be usable in community out-patient pharmacies. It is also expected that the program will interface with the laboratory test program which has recently been developed by Dr. Howard Sussman. Once this interface has been accomplished, it will be possible to utilize prescription information in evaluating laboratory test results. Thus, laboratory evidence of inadequate renal function might serve to alert the physician not to administer usual doses of a drug that is excreted entirely by the kidney. Conversely, the artifactual effects of certain drugs on laboratory test results can be detected and appropriate warnings provided in the clinical laboratory.

COLLABORATIVE RESEARCH PROJECTS

Investigator: Christos Constantinou
Dept. of Surgery, Div. of Urology
Project Began November 1969

Project: C_CONSTA. UROL
Realtime

Studies are being done to improve the clinical appraisal, follow-up and management of patients with neurogenic bladder dysfunction secondary to spinal cord injury or disease. In particular, we are trying to determine the feasibility of utilizing computer-based techniques of information data storage, processing and retrieval in this patient population.

Of particular interest is the mechanism of initiation of peristaltic waves and the quantitative description of the process through which continuous urine flow at the kidney is transformed to discrete peristaltic waves. The significance of this transformation lies in the rhythmic properties of the output sequence of peristaltic waves, and the stroke volume of each wave. These two variables alone provide the most convenient measures for ureteral function evaluation. A hypothetical model has been developed to simulate the generation of peristaltic wave trains with the objective of developing a manageable description of their temporal sequence. Spike train analysis traditionally employed in statistics has been used for this purpose. It is expected that in the course of development of the mathematical model, a better understanding of what is responsible for the observed process will result. As a consequence, it will be possible to make inference as to whether the ureteral system is driven by a neuronal pacemaker or is myogenic.

ACME is being used for real-time data acquisition and feedback, and for analysis. Analog data collected from anesthetized animals in surgery is transmitted via the interface box to the 1800 and 2741 output received in the operating room during the experiment.

Investigator: Eugene Dong
Dept. of Surgery, Div. of Cardiovascular Surgery
Project Began November 1970

Project: E_DONG. LAB
Realtime

The primary purpose of the project was to study the principles of mammalian heart rate control, with particular emphasis on the sino-atrial node--the controlled pacemaker which governs heart rate. Since understanding the pacemaker requires a mathematical description of its behavior, a concomitant objective was to quantify observed heart rate data.

The contributions of this research should be helpful in interpreting the functional status of the central nervous system from observed heart rate data. They are basic to understanding respiratory sinus arrhythmia and ventriculophasic arrhythmia and are also pertinent to establishing control criteria for artificial heart assist and replacement devices.

Collaborative Research Project Descriptions (cont'd.)

The control of mammalian heart rate was studied by first eliminating normal central nervous control to the heart and then artificially evoking impulses in the nerves leading to the heart. The work was restricted to an analysis of the effect that vagal nerve impulses have on resulting decreases in heart rate.

In these experiments, the heart was placed in an autonomous state by severing both cervical vagal nerves and administering the beta adrenergic blocking agent propranolol. Heart rate responses were then elicited in 14 anesthetized dogs by electrical stimulation of the cut end of the right vagal nerve. Each stimulation was varied in intensity and in time relative to the heart cycle.

Computer controlled stimulations yielded reproducible temporal sequences of heart periods for the two testing schedules employed. For one schedule, the system was impulsively perturbed by one stimulation. For the other, a train of stimulations reproducibly forced the system to a second state, where it was either perturbed further by one stimulation or permitted to relax to the autonomous state. The new measurements obtained demonstrated that existing mathematical models of heart rate control functions are incomplete.

A model consisting of coupled, first-order, nonlinear differential equations was formulated to predict the heart period first lengthened by one stimulation; the measured periods ranged to three times the autonomous period. For [illegible] related the dependence of heart period [illegible]

on the intensity and relative timing of
the hypotheses that

concentration of the neurotransmitter
ses in negligible time and then exponen-
msec half-life time--one-twentieth the
to relax to the autonomous rate; and
, 175 msec period prior to the end of
is continuously controlled.

the stimulation. The model supports [illegible]

(1) after one stimulation, the [illegible] at the heart's pacemaker ris tially decreases with a 400 total time for the pacemaker
(2) except for an uncontrollable each heart cycle, heart rate

ir difference equation, describes the
en the input and output pulse trains of
oscillators. Necessary and sufficient
given for synchronization of input and
ental frequency. The derived analyti-
to the analysis of heart rate data ob-
uency, vagal nerve stimulations.

A second model, a first-order nonlinea temporal sequence of time delays betwe a class of injection-locked relaxation conditions on the nonlinear term are g output when they are of similar fundam cal results are shown to be applicable served under repetitive, constant freq

are as follows:

Other extensions to previous research

e above the autonomous rate which are
gal nerve stimulation are reported;
e of the transient relaxation of heart
following the cessation of stimulations;
smallest observable time for a stimula-
d the dependence of this time on the
h;
nsiveness to a stimulation is shown to

(1) large increases in heart rat paradoxically produced by va
(2) quantitative analysis is mad rate to the autonomous rate
(3) measurements are made of the tion to affect heart rate an unaffected heart cycle lengt
(4) the decrease in system respo

Collaborative Research Project Descriptions (cont'd.)

be dependent upon the short term past history of stimulations;
(5) measurement is made of the recovery of responsiveness that occurs following the cessation of stimulations; and
(6) the time required for complete recovery of responsiveness is shown to exceed the total time required for heart rate to return to the autonomous rate.

During the latter part of this fiscal year, a part-time ACME programmer has developed additional graphics tools for this project. Scatter plotting of experimental parameters, and historical plotting of treatments are included.

Investigator: Eugene Dong
Dept. of Surgery, Div. of Cardiovascular Surgery
Project Began July 1970

Project: E_DONG. PATIENT
Realtime

ACME has been used to enter and store data from over 1800 cardiac surgery patients. Data includes age, diagnosis, admission data, operation date, discharge date, and operation description.

Using this data base, weekly and monthly operating schedules are generated. Survival tables are produced for the transplant patients, and some correlation work is done with the entire data base. Tables of patient data (ordered by hospital number and last name) are also generated.

Investigator: Alan Duffield
Dept. of Genetics
Project Began December 1968

Project: VABACON. GAME
Realtime

In this "on-line" application, the decision-making capabilities of the computer are coupled with those of an operator to direct the operation of a Finnigan 1015 quadrupole mass spectrometer.

The computer is used to actively direct the operation of the mass spectrometer by controlling the mass filtering system of the instrument. It is used to recognize and control the voltage changes which define mass peaks and enable the rapid collection and presentation of data.

The computer traces out peak shapes of the known masses in a reference gas allowing the operator to determine correct mass positions, and to enter any shifts in calibration into the computer register for compensation automatically.

While taking data, the information may be displayed on an oscilloscope or recorded on magnetic tape. Once data is acquired, the structural identification of organic compounds is made from orthogonal coordinate or spiral base plots

Collaborative Research Project Descriptions (cont'd.)

of mass spectra made by computer direction of a CALCOMP plotter. The system is also used to analyze Gas Liquid Chromatograph effluent, permitting the structural identification of mixtures of organic compounds. This last application has important uses in the analysis of organic compounds from biological sources.

Investigator: James Fries
Dept. of Medicine, Div. of Immunology
Project Began July 1969

Project: J_FRIES. DATABANK
Non-Realtime

This project involves a primary clinical information retrieval system which interrogates computer-stored accumulated patient experience and obtains data for direct answers to clinical and research questions.

The present non-indexed disorganized methods of maintaining medical records represent an obstacle to good patient care, a hindrance to medical education and a limit on the quality of medical research. This project attempts to remove these obstacles by implementation of a structured method of data collection and entry of the structured data into a computer databank. Search programs operating on the databank provide prompt, accurate recall of past experience and correlations with new developments. The databank is contributed to and used by physicians in private practice as well as those of the university center. The structure of the computer file is designed to maximize "search" efficiency and a library of output program allows the immediate answering of many millions of possible clinical questions by retrieval, tabulation, and statistical manipulation of primary patient data.

A systematic method of recording serial clinical and laboratory information has been developed and clinically tested. The method has two important features:

(1) As a "time-oriented record" it displays changes in parameters with respect to time so that the entire past course of the patient can be quickly analyzed by the physician.
(2) It replaces rather than adds to present records.

These features improve physician acceptance as well as scientific validity. The chart reduces redundancy and decreases total "paper work" by the physician.

Factual clinical information is displayed in a two-dimensional time-oriented format, listing parameters on the vertical axis and time on the horizontal. Time is represented by successive "patient-visits" in which each encounter of a patient and a physician is considered a data-gathering point and forms one column of the chart. Laboratory data and the therapeutic program are similarly entered on the record.

If the course of a patient may be displayed in two dimensions, then a computer databank may be considered a three-dimensional array of data. Data

Collaborative Research Project Descriptions (cont'd.)

thus arranged may be located directly by the use of three coordinates, and search procedures may be operated on the parameter axis, the time axis, or the patient axis with equal ease. A search may be addressed to various parameters of one patient, to changes with time, or to findings in groups of patients. Interrelationships of parameters are easily investigated, and questions involving the time axis, such as prognostic importance of variables or response to therapy, may be answered.

In our system, information is entered into an IBM 360/50 digital computer by use of a typewriter terminal. Ten new patients, fifty patient visits, and about 20,000 pieces of data are entered each week. Three hundred and fifty-two entries are made for each patient visit. Daily search procedures acting on the databank provide research data, support individual clinical decisions, and develop experience-based data for clinical teaching.

Our computer is frequently consulted instead of a traditional medical-library-based review of the literature, as the databank often contains a series which is larger, more recent, more accurate, and more directly applicable to our patient population. Moreover, if expenditure of physician time is considered, consultation with the computer is generally less expensive than utilization of the library.

Computer storage of detailed clinical information has been feasible, desirable, and useful in our clinic, and by extension, should have wide application within medicine. The clinical databank is a powerful tool which can serve as the central focus for teaching, research, and patient-care activities. By development of improved methods of handling and analyzing patient data the clinician and the clinical researcher may be able to effectively utilize the increasing flow of biological information from our laboratories. Design of improved clinical charts, methods of computer file organization, formats which output data should assume, and potential interchange of clinical information between institutions are crucial medical questions, and evolving answers to these questions will play an important part in determining the quality of future health delivery systems.

Investigator: Jerome Gold
Dept. of Radiology, Div. of Diagnostic Radiology
Project Began October 1969

Project: J_GOLD. SWALLOW Realtime

This project involves the study of esophageal blood flow.

One study compared the esophageal blood flow of normal subjects and subjects affected with a connective tissue disease (CTD). Such diseases are characterized by esophageal motility abnormalities. The hypothesis was that these abnormalities were related to impaired blood flow. The blood flow was indirectly assessed by measuring the time for intraluminal esophageal temperature to rise to normal following ingestion of 5 ml. swallows of 0.5^{o} C. ice water. With the subject sitting, 2 small thermistors were inserted into the esopha-

Collaborative Research Project Descriptions (cont'd.)

gus, one located in the distal 1/3 and the other in the proximal 1/3 near the junctional zone of smooth and striated muscle. Thermistor rewarming curves were recorded and the amplified signals collected by ACME through the 1800 for storage and analysis. Thermistor curves were analyzed (deg/sec) for several portions of the rewarming time. A significant difference existed between the slopes of the first half rewarming in CTD patients and normals in the lower esophagus. Although of lesser magnitude, a significant difference also existed between the slopes of the first half rewarming in the upper esophagus. Preliminary evaluation suggests that the time for first half rewarming may also be significantly different between the two groups. These data provide additional support for the hypothesis that esophageal blood flow is decreased in some CTD and may be related to their manifest motor dysfunction.

A second study, utilizing laboratory animals, measured esophageal blood flow with injections of radioactive material. A catheter-type semi-conductor beta radiation detector system (catelix) was used. A detector was passed into the distal esophagus. Two millicuries of ^{86}Rb were injected intravenously, and ACME made continuous recordings of the Catelix counts per unit time over a ten-minute period. After ten minutes, another 2 mCi of ^{86}Rb were injected and counts again recorded. After serial determination, a final 2 mCi of ^{86}Rb were injected and the animal sacrificed 60 seconds later. The esophagus was removed. Counts were then recorded at different levels in the esophagus and correlated with the amount of ^{86}Rb per gram as determined by counting the tissue in a well-type scintillation counter. The data will be subjected to statistical analysis to evaluate the linearity of count rate with dose of administered isotope. The area under the curve generated by changing count rate after the isotope is administered may be used to calculate cardiac output.

By substituting another isotope and different dosages, serial determinations of esophageal blood flow are feasible in humans.

Investigator: Donald Harrison
Dept. of Medicine, Div. of Cardiology
Project Began 1968

Project: DCHARRIS. CATH_LAB
Realtime

Fourier analysis is being performed on left ventricular pressure curves. Their component points are stored for frequency spectrum quantitation. This study is done to determine the frequency response which the equipment must have in order to represent the data accurately. The results are applied to hemodynamic studies in both patients and experimental animals.

ACME is used for data handling for cardiology research on dogs. Normal dogs and dogs which have undergone various surgical procedures are involved in the study. Numerous hemodynamic values collected under a variety of experimental conditions are filed for each dog. These files provide a convenient source of reference and comparison for a number of cardiology researchers.

Collaborative Research Project Descriptions (cont'd.)

Investigator: Leslie Kadis
Dept. of Anesthesia
Project Began July 1971

Project: L_KADIS. VISAEP
Realtime

The purpose of this project is to develop a model for experimental pain that will be clinically applicable. The model, based on the gate control theory of pain proposed by Melzack and Wall, will be tested in man and in animals.

Sensory information from painful stimuli travels from peripheral receptors to synapse with second order neurons ("T" cells) in the substantia gelatinosa in the spinal cord over both large, fast conducting fibers, and small, slow conducting fibers. Melzack and Wall proposed that transmission to the T cell in the spinal cord depends on the balance between large and small fiber activity. For example, when large fiber activity predominates, the threshold for excitability of the T cell is raised, or, in other words, the gate is closed. Transmission of information about painful stimuli is then impaired. We will study the role of disorganization of sensory information (change in the balance between large and small fiber activity) on transmission of neural impulses in the spinal cord in cats. We also will assess the modification of spinal cord activity by narcotics.

Another aspect of the Melzack and Wall hypothesis is that there is a separate pathway for rapid transmission of sensory information directly to higher centers with feedback to the "Gate" to change the threshold for excitability of the T cell. The averaged evoked cortical response (AER) to somesthetic stimulation reflects both transmission at the spinal cord level and central processing, and it is our hypothesis that individual responsivity to painful stimuli can be predicted from the pattern of response of AER to graded intensity stimuli. We plan to develop quantitative methods to test this hypothesis using experimental pain in man.

We also plan to evaluate psychophysiologic aspects of experimental pain in man, as well, and relate these to the pattern of response of the AER. We know, for example, that individuals whose perceptual style is such that they require perceptual clues from the external world, or who, in their interpersonal relationships are extroverts, or who have little anxiety, are most tolerant of pain. The project will assess some aspects of personality (the introversion - extroversion parameter) as well as cognitive and affective variables and relate these to patterns of response of AER to graded intensity stimuli.

Finally, the project will utilize the methods developed above and assess the relationship between clinical and experimental pain in patients who are suffering from cancer and who have metastases to bone. In this homogenous group of patients we will correlate patterns of AER with clinical pain, response to drugs, and methods of coping with illness to assess the relative importance of these variables.

Collaborative Research Project Descriptions (cont'd.)

Investigators: Larry William and
Saul Rosenberg
Dept. of Medicine, Div. of Oncology
Project Began 1972

Project: S_ROSENB. MEDONCOL
Non-Realtime

The Division of Oncology has recently begun to experience an increasing need for a versatile medical record data processing system to serve both patient care and research requirements. To achieve these goals we are currently attempting to modify a computer-based time-oriented medical record system developed by the Division of Immunology.

Specifically, we are using a versatile input program to store approximately 450 different patient care parameters for each clinic visit. Thus, we are currently inputting most of the hard data from the clinical charts of our patients. Once a suitable data base has been established, we hope to be able to obtain a variety of outputs. For example, we hope to nimbly retrieve, compare and display actuarial survival curves of patients treated with competing therapies; search for laboratory tests which are of prognostic significance; find patient subsets with uniquely good or bad responses to treatment, etc.

Initially we are exploring the advantages of this record keeping system on the patients in the medical oncology clinic. If it proves feasible, we hope to expand and generalize the programs so devised to apply to other problems in oncology and general medicine.

A new time-oriented medical chart is an essential and unique feature of our current system. Information is recorded in an efficient, basically flow-sheet mode in the most objective fashion possible. Then this material is input via the typewriter terminal into the 360/50 computer. The chart serves as a hard copy of the patients' record and satisfies all medical-legal requirements.

Investigator: Howard Sussman
Dept: Stanford Univ. Hosp.
Clinical Lab Pathology
Project Began November 1969

Projects: H_SUSSMA. LABSYSO
H_SUSSMA. LAB_PAT
H_SUSSMA. c1050937
Realtime and Non-Realtime

Over time, the work load of the Clinical Laboratory has steadily increased. At present, in the Chemistry and Hematology areas of the Clinical Laboratory, over 2000 tests per day are performed on approximately 400 specimens. The increased work load has put such a strain on the manual system that serious problems have developed in specimen handling, and the gathering and dissemination of information.

A Clinical Laboratory Information System has been developed at Stanford Hospital using the ACME system. Mark-sensed card input to the patient data

Collaborative Research Project Descriptions (cont'd.)

Investigator: Gerald Reaven
Dept. of Medicine, Div. of Metabolic
Diseases and Endocrinology
Project Began January 1969

Projects: G_REAVEN. PAT_DATA
G_REAVEN. DISPLAY
Non-Realtime

We are involved in studies of the relationship of risk factors such as cholesterol, etc., to coronary heart disease in the community. This study involves the use of ACME in three major ways:

(1) We utilize ACME's data storage and retrieval capabilities. The data collected consists of variables describing the demographic, medical and behavioral characteristics of the subjects in the study. Our first major study was just recently published and the ACME facility was used almost exclusively.
(2) We use the library of statistical programs in conjunction with the retrieval capabilities of ACME to analyze community data.
(3) We have used the graphic capabilities of ACME to develop an interactive graphic pattern recognition procedure which describes the underlying distribution of the data obtained from the community. It also is an exploratory mechanism to determine if the distribution may consist of sub-component populations. We are also capable of estimating in another graphic subroutine the parameters of the resulting component populations if they are bivariate Gaussian.

A second major research activity consists of developing mathematical, physiological and computer models describing the production, distribution and removal of certain metabolites important in the study of diabetes mellitus and atherosclerosis. In the past, we have developed and updated a model describing the distribution and degradation of insulin in man and dog. We have, in conjunction, developed graphic computer techniques to aid us in this model building. The distribution and uptake of glucose in man has also been considered and a paper is forthcoming describing a comparative study of the dynamics of the glucose and insulin systems. A prior paper described the efficiency of glucose uptake in normal and diabetic man and has utilized both the graphic and statistical capabilities of ACME.

We are now developing models that describe the mechanisms of insulin production in man and dog and the effect of glucose on this secretory system.

Another important aspect of our work concerns inpatient metabolic problems, and we are at present involved in establishing a data file on ACME for two specialty clinics. We hope to use ACME's storage, retrieval and statistical capabilities to analyze this data in order to explain various mechanisms that may be responsible for some of the etiology of maturity onset diabetes and atherosclerosis.

We are also involved in the development of a nationwide clinical trial to test the "lipid hypothesis" and are utilizing ACME to develop statistical models which can explain the interrelationship of the parameters associated with this clinical trial.

Collaborative Research Project Descriptions (cont'd.)

files is provided using a mark-sensed card reader tied into the IBM 1800 at ACME. The system prints worklists for the technicians and monitors the status of the tests which have been ordered. At the end of each day, the patient results are printed in a form suitable for chart copies or lab files.

A multiple analyzer, the SMA 12/60, has been interfaced to the IBM 1800 to provide an efficient way of inputting test results to the patient files. In the future, more instruments will be interfaced.

At present, the Clinical Laboratory Information System is in pilot production mode at the Hoover Pavilion, a small hospital adjacent to Stanford. Using the lessons learned from operations there, the system will eventually come into production for the whole of Stanford Hospital.

Investigator: George Swanson
Dept. of Anesthesia
Project Began September 1969

Project: G_SWANSO. THESIS
Realtime

The respiratory laboratory in the Department of Anesthesia has been involved in the investigation of dynamic experimental techniques for the study of the human respiratory control system. Our goal has been to develop non-invasive experimental techniques in which we can assess human respiratory drug effects in terms of specific physiologic mechanisms which contribute to respiratory control.

The classical steady state and rebreathing experimental methods are restricted to assessing drugs in terms of an integrated respiratory effect. Our experimental approach uses the temporal aspects of a ventilatory response to an end-tidal CO_2-O_2 stimulus to observe and isolate the contribution of specific mechanisms such as the central chemoreceptor, cerebral blood flow, carotid body and lung to brain circulation time.

For the past year we have been involved in a theoretical study of dynamic experimental design. We have developed a dynamic end-tidal forcing technique. The basic idea is that the end-tidal time histories of CO_2 and O_2 can be selected for model discrimination and for minimizing the uncertainty in a model parameter estimate.

The design of experiments depends upon computer simulation of alternative models. We have implemented a descriptive computer simulation of the respiratory system. The simulation is general enough to encompass alternative configurations of interest. We have also validated via computer simulation, a theoretical method of selecting the end-tidal CO_2-O_2 forcing function for minimizing the variance of estimated model parameter.

The experimental design is enhanced through man-computer interaction. This concept was explored on ACME using the Tectronix display scope. Alternative forcing functions were generated and evaluated.

SERVICE PROJECTS

Investigator: Malcolm Bagshaw
Dept. of Radiology, Div. Radiation Therapy
Project Began December 1968

Project: M_BAGSHA. SUMMARY
Non-Realtime

The project contains datasets for four general purposes, listed below in the order of disk storage space occupied.

The purpose of the first two groups of files and programs is to allow the medical staff to conduct research on various forms of cancer and make comparisons of various methods of treatment.

(1) Files of records of general data on all patients of the Radiotherapy Division are kept from about 1968 to the present with the necessary programs for input and retrieval of the data. The retrieval programs are designed to allow the radiologist himself to select patients based on any desired criterion, print out desired information about each, or create a subset of these patients for further analysis.
(2) Another set of files contains records of detailed data on all patients with Hodgkin's Disease, along with the necessary programs for input and retrieval of the data. The retrieval programs will choose records of patients selected on any combination of desired criteria, print out desired information about each, and perform survival or remission analysis on the selected group.
(3) Mathematical programs have been developed for use by the radiologic physicists for calculations concerning beam characteristics, depth dose tables, analysis of curves, etc.
(4) Statistical programs are available to obtain Berkson-Gage or Kaplan-Meier survival tables from data input by the user.

Investigator: Walter Bodmer
Dept. of Genetics
Project Began December 1968

Project: W_BODMER. POPGEN
Non-Realtime

Since the original discovery of sera with isoantibodies directed against human white cell antigens, the use of statistical techniques has played a major role in the discovery and analysis of human white cell antigen systems. Stanford's Department of Genetics has long been involved with the development of statistical analysis. The computer has always been one of our most basic tools.

White cell antigens are now known to constitute the major human histocompatability system, called HL-A. They form the basis for tissue typing for clinical transplantation. Recent data has also shown significant correlation between the HL-A system and certain diseases, notably Hodgkins disease. It is also related to certain other cancers and to autoimmune diseases.

Service Project Descriptions (cont'd.)

The analysis of 2 x 2 associations between serum reactions for the definition of antigens in the HL-A system was pioneered in 1962 by Van Rood and has been further developed and extended by ourselves and others. It has been the basis for the definition of most of the presently known antigens of the HL-A system. The main principle involved is the recognition of groups of associated sera which share antibodies and can therefore be used to define the corresponding antigen. In addition, the analysis of association between antigens in populations has proved an important adjunct to understanding the genetic control of the HL-A antigens.

The improvement of serological techniques for the detection of white cell antigens has greatly helped in their definition. However, in order to have a basis for the original identification of new antigens and characterizations of sera, we find that it is still necessary to use the same statistical procedures which were originally essential for the definition of the antigens. Over the years, considerable effort has been invested in developing a library of programs for the analysis of serological data. This set of programs deals with all aspects of our work:

(1) input and organization of data
(2) characterization of sera
(3) assignment of antigen phenotypes
(4) calculation of population frequencies with respect to complex combinations of phenotypes
(5) fitting of complex genetic models to the phenotypic frequencies.

There is no doubt that the availability of the time-sharing system has greatly increased our ability to handle and analyze the large bodies of data involved in our research. Programs are designed for use by people who have no detailed programming knowledge. They include appropriate prompts for every stage of data input. During input, the data is monitored in various ways to verify that the input corresponds to expectations. Then the data is put into a standard format for subsequent ease of analysis. The computer is used at every stage of data analysis and interpretation. Examples are: the selection of subjects of a given phenotype to use for absorption, and the assignment of antigen phenogypes based on complex patterns of reaction to defined sets of sera. We have also developed programs for displaying population data on complex patterns of phenotypes and for the analysis of family data.

Investigator: Edward Bunnenberg
Dept. of Chemistry
Project Began December 1970

Project: E_BUNNEN. CHEM
Realtime

The main goal of this project is to achieve an effective interactive computer-assisted operation of a highly specialized type of spectrophotometer--a magnetic circular dichrometer. The utilization of organic chemical and especially biochemical applications of magnetic circular dichroism will allow the following:

(1) an increase in the operational sensitivity of the instrument

Service Project Descriptions (cont'd.)

through the application of digital averaging and smoothing techniques. This is especially important for this instrument because of its inherent single-beam operation;

(2) the measurement of compounds having relatively strong signals much more rapidly;

(3) the extraction of quantitatively meaningful spectroscopic parameters from the magnetic circular dichroism spectra. This is of crucial importance for much of the work and requires the implementation of generalized curve deconvolution and fitting programs.

The first objective was demonstrated in the use of the MCD instrument with on-line computer connection to analyze lunar soil extracts for metalloporphyrins.

Preliminary experiments indicate that the time required to scan through the MCD spectrum of a routine sample, i.e., one in which the signals are relatively strong, can be materially decreased through on-line computer operation of the MCD instrument.

Significant progress has been made in connection with the third objective, the extraction of quantitatively meaningful spectroscopic parameters from MCD spectra, although fund limitations have necessitated this accomplishment by off-line (curve tracer) rather than on-line computer assisted operation.

Investigator: Howard Cann
Dept. of Pediatrics
Project Began December 1968

Project: H_CANN. GUAT
Non-Realtime

This project is an investigation of factors which affect frequencies of genes controlling various human heritable characters. The extent to which selection, genetic drift, and migration affect frequencies of certain human genes is being assessed and specific selective factors are being sought. Environmental, cultural, and historical conditions favorable for this type of study have been found in settlements of Mayan Indian descendants in the Lake Atitlan Basin of southwest Guatemala. The local microgeography and mating patterns appear to enforce a high degree of genetic isolation for each of a number of Indian towns and villages ringing Lake Atitlan. These high mortality populations provide the opportunity to study selection on human genetic polymorphisms.

The ACME system stores demographic, clinical and socioeconomic data collected from large samples of inhabitants of each of eight isolated Indian villages. A master file for each village has been developed to link laboratory, demographic, and anthropological information on each individual. An indexing system allows quick retrieval of each bit of data collected on a given individual, as well as a means of linking him into a family unit, thereby retrieving similar data from other members of his nuclear family. Using the various data collected for and generated by this project, the ACME computer is now being employed for the final analyses which will include maximum likelihood

Service Project Descriptions (cont'd.)

estimation of gene frequencies, analysis of variation in gene frequency distributions, estimation of coefficient of kinship from pedigrees, segregation analysis of polymorphisms, comparison of fertility and mortality by genotypes and association of clinical, epidemiologic and socioeconomic variables with genotypes.

This project will also contribute information on the genetic taxonomy of the American Indian. Families of large size, characteristic of the study population, will afford excellent opportunities for medical genetic investigation of inherited diseases encountered in our field activities and for studies of genetic linkage.

Investigator: Luca Cavalli-Sforza
Dept. of Genetics
Project Began March 1971

Projects: L_CAVALL. PAVIA
L_CAVALL. JUDY
L_CAVALL. KEN
L_CAVALL. LAURA
L_CAVALL. MARK
Non-Realtime

The Evolutionary Rate in Man

Models have been developed for the reconstruction of phylogenetic trees. These trees are developed to indicate not only relationships between and among populations, but also to indicate the amount of time elapsed since the separation of populations. Simulation is used (particularly in the determination of the amount of expected error in phylogenetic tree reconstruction). Computer analysis is necessary in the construction and analysis of migration matrices, genetic distance matrices, and gene frequency data.

Changes in Man's Genetic Composition Brought About By the Spread of The Neolithic

The Neolithic revolution has undoubtedly brought about some changes in the genetic composition of man. The rate of spread and mode of spread have been analyzed. Geographic maps with isochrones of the spread were drawn by the computer, fitting the radiocarbon data to a surface. Analysis of the relation between radiocarbon time with the more accurate tree time is now being carried out with polynomial fitting and search for periodicities. The genetic effects will now be studied using the gene frequencies of various polymorphisms, anthropometric measures, etc. In addition, simulations have been set up to test the validity of the methods of analysis used.

Patterns of Inheritance in Behavioral Traits Such as Schizophrenia

Models have been developed, mainly using computer simulations, to throw light on the possible modes of inheritance of such traits as schizophrenia. It is hoped that such factors as penetrance, polygenic or single gene inheritance can be brought into their proper relative perspectives.

Service Project Descriptions (cont'd.)

The Analysis of Record Linkage Data and Pedigree Information Based on Material Available from Parish Books, Census Data, Etc.

There is an on-going program of analysis of data, particularly from the Parma Valley of Italy. This data is obtained from parish books and from municipal records, as well as from Italian censuses. Such information as degree of inbreeding in the population, amount of migration, changes in life expectancy, family size, isonymy, etc. will be obtained from this study.

Investigator: Avram Goldstein
Dept. of Pharmacology
Project Began August 1970

Project: A_GOLDST. OFFSTUFF
Non-Realtime

The computer is used for filing and analyzing data from a clinical study on the use of methadone in the treatment of heroin addiction. The study is designed to answer questions about the efficacy of methadone in stopping heroin use and rehabilitating heroin addicts, to determine if there is an optimal dosage stabilization level for most patients, and to discover just what that dosage level is.

The subjects of this study are patients of the Santa Clara County Methadone Program and of several "sister" programs in this region. Data from several hundred patients is collected, in order to obtain a statistically valid sample, and the subjects are monitored in several ways:

(1) Urine samples are obtained on a random basis with a basic frequency of once in five days from each person. These samples are tested for the presence of morphine (heroin) and other drugs (barbiturates and amphetamines), and thus provide concrete evidence of the patient's progress or lack of progress, as measured by his continued use of heroin. ACME is used to file and analyze the results of the urine test, and also to generate the lists of random numbers which determine which patients give urine samples on which days, maintaining the desired frequency.

(2) Progress questionnaires (30 items, multiple choice) are administered to each patient at the time of admission to the methadone program and at regular intervals thereafter. These questionnaires provide data on physical symptoms while on methadone, current use of heroin, criminal activities, and occupation. This information is stored and analyzed statistically by ACME to discover correlations between success on the program and other characteristics, such as current dosage, age, sex, holding a job, etc.

(3) Symptom questionnaires are various short questionnaires (4-11 items) which deal primarily with physical symptoms and which are used to measure the patients' comfort on a particular dosage level or schedule. These questionnaires are administered more often than the progress questionnaire, usually weekly or daily, and have provided data for studies on determining the ideal dosage stabilization level, and on comparing once-daily and twice-daily administra-

Service Project Descriptions (cont'd.)

tion of methadone. This type of questionnaire will also be used in an upcoming study comparing the action of methadone and long-acting methadone (levorotatory-α-acetylmethadol, abbreviated as LAM). One hundred patients will be involved in this study (including control subjects) and ACME will again be used for performing a variety of statistical analyses.

No conclusions have been reached as yet concerning the best medication (methadone or LAM) since the study is still in the planning stages. The investigations as to the best dosage level and dosage schedules of methadone have given conclusive results, however. It has been shown that a dose of 50 mg per day is adequate for most patients, and that administering the entire dose once a day is best in terms of patient comfort.

There is a great mass of data involved in these studies, due to the number of questions being investigated and the large number of subjects about whom data is being collected. (The large number of subjects is necessary in a clinical trial of a drug to avoid having results biased by individual idiosyncrasies.) To record this mass of data by hand would require a great many man-hours; performing the complex and selective computations for the statistical analyses without the use of a computer would probably be impossible. In addition to its speed, ACME's interactive capability gives much-needed flexibility in the use and handling of data.

Since the methadone program is an ongoing treatment facility, using a drug and treating a disease about which there are still many unanswered questions, the need and opportunity for further study can be expected to continue for several years. Continued availability of the ACME facility will be vital to the success of such studies.

Investigator: Scott Grant
Dept. of Surgery, Div. of Ophthalmology
Project Began October 1971

Project: S_GRANT. CORNEA
Non-Realtime

The endothelial membrane of the cornea is being studied. This membrane is responsible for maintaining the proper hydration of the cornea via an active pumping process. One way of attacking the problem of understanding this pump is by the use of radioactive isotopes of Na and Cl. These tracers are used in perfusion studies of the endothelium. The amount of data gathered from each experiment is copious. The analysis of the results would require approximately six hours of uninterrupted manual calculation. Due to the delicacy and sensitivity of the mounted corneas, it has been necessary to repeat the experiments quite often to obtain statistically relevant results. The use of ACME in data analysis has allowed a job that once took six hours to be reduced to a fifteen to twenty minute period for data entry. More experiments can be carried out per week. Most important, the accuracy of the calculations is now unchallenged. This work has proceeded smoothly, providing further insight into this difficult problem.

Service Project Descriptions (cont'd.)

Further work has been initiated using ACME in the realm of mathematical modeling. One of the still unanswered questions about the cornea is why it is transparent. Electron micrographs are used to provide data on the ultrastructure of the cornea. This information is applied by the computer to evaluate the electromagnetic scattering of the cornea. An analysis of this sort is impossible without the assistance of ACME due to the several thousand data points of input.

Investigator: Paul Green
Dept. of Biosciences
Project Began September 1971

Project: P_GREEN. AVENA
Realtime

Biological Significance

The growth of plants is governed by a number of hormones each of which is a low-molecular-weight compound of known structure. These molecules are "keys" but the lock into which they fit is obscure. We treat the growing plant-object of choice, the oat (Avena) coleoptile, as a "black box" which we study by observing output (growth rate) as a function of step shifts in the driving force (turgor pressure). It can be shown that the growth process contains a governor or feedback system, with the feedback term coupled to the braking or deceleration component of the governor. The action of the hormone appears to involve a resetting of the coupling, giving less braking action, hence higher rate. A detailed characterization of the actual responses allows the description of a chemo-mechanical model for the growth process.

Computer Use

The analysis requires very accurate information of growth rate (accuracy of one part in 80,000, per minute). This is achieved by feeding voltage from a linear displacement transducer into a digital voltmeter (4 1/2 places). The information is then converted to paper tape using a teletype. As the experiments run for 12 hours, with a reading being taken every minute, this method keeps the information in the laboratory until the experiment is over and judged worthy of analysis. If so, the tape is read in, and length, rate, rate of change of rate, ln rate, etc. are computed. The change in various parameters allows us to characterize the action of ageing of the tissue, turgor pressure, and hormone action in abstract, but measurable terms.

Pertinence to Man

The system is a model for the study of the mechanisms for the cessation of growth (ageing). It also allows study of the action of a hormone of known chemical composition (indole acetic acid) on a biophysical system where the physical components (turgor pressure and wall parameters) are relatively well understood.

Service Project Descriptions (cont'd.)

Investigator: Samuel Kountz
Univ. of California Medical Center, San Francisco, Dept. of Surgery
Project Began December 1968

Project: SLKOUNTZ. KIDNEY
Non-Realtime

The Transplant Service at the University of California uses ACME in the selection of recipients for renal homotransplantation. The computer has been programmed to include data from over 100 patients who are on chronic hemodialysis awaiting a cadaver transplant. When a cadaver kidney becomes available, similar data is obtained about the donor's body. The computer matches donor information with recipient information. Matched recipients are then brought into the hospital for transplantation.

ACME is also used as a follow-up tool to predict the onset of rejection crisis by monitoring renal function and hemodynamic changes. Renal function is measured by the single injection of radioisotopes. The disappearance curves are analyzed by the computer and compared with previous determinations. This has provided a very accurate method of following patients and detecting early incipient rejection.

Using all of the available data on transplant patients, ACME generates survival statistics. These are analyzed with the aim of finding factors significant to rejection and survival.

Investigator: P. Herbert Leiderman
Dept. of Psychiatry
Project Began December 1968

Project: PHLEIDER. PREMIE
Non-Realtime

Studies of maternal behavior in non-human mammals have suggested that the degree of interaction permitted between mother and infant in the postpartum period will influence later maternal attachment and infant development. The hypotheses raised by these studies can be explored with human mothers and infants through manipulation of care procedures of mothers and newborns in the immediate postpartum period.

Assessments of each mother and her infant are made periodically during the time the infant is hospitalized and during the first two years at home. Three major areas are included in these assessments:

(1) maternal attitudes regarding her relationship with the child as reflected in responses to interviews and questionnaires;
(2) maternal behavior observed during routine caretaking of the infant; and
(3) the behavioral development of the infant.

A pilot study was conducted to determine the feasibility of changing premature care procedures in order to study the effects of interactional deprivation in the neonatal period on maternal attitudes and behavior. Forty-one mothers

Service Project Descriptions (cont'd.)

were permitted to enter the nursery and touch or handle their premature infants in incubators as early as the second day after birth. The feasibility of admitting mothers to the premature nursery without increasing the risk or occurrence of infection, or disrupting the organization of the care of the infants, was demonstrated.

We are now conducting a long-term study based on this pilot model to delineate the differences in commitment, feelings of competence, and behavior in the two differentially treated groups of mothers and to relate their behavior to the motor and mental development of the infants.

Investigator: Harden McConnell
Dept. of Chemistry
Project Began February 1971

Project: H_MCCONN. ABSORB
Realtime

ACME is used for analysis of experimental paramagnetic resonance spectra and calculation of theoretical spectra. These paramagnetic resonance spectra arise from the application of the "spin label" technique to problems involving biological macromolecules. Biological problems which are currently being studied include cooperative oxygen binding to the protein hemoglobin, the relation of molecular orientation and motion to function in biological membranes and membrane model systems, and development of quantitation assay techniques using spin labels.

The paramagnetic resonance spectra that are obtained in spin label studies are recorded as the first derivative of an absorption curve. The area under the absorption curve is proportional to the number of spin labels giving rise to the signal. Also, spin label spectra give information on changes in conformation or motion of a macromolecule. Frequently, these changes are detected as a small change in the paramagnetic resonance spectrum. Quantitative measurement of spectral changes requires normalization of spectra from a series of experiments. ACME is used to compute the double integral of the experimental spectrum and then to regenerate a normalized spectrum. Subtraction and addition of spectra are used to analyze experimental data. In addition, experimental spectra are often analyzed by comparison with theoretical spectra which are calculated using ACME.

Interfacing Electronparamagnetic Resonance Spectrometers to the Computer

Models E-4 and E-12 of the Varian EPR Spectrometer have been interfaced to ACME for purposes of real time data acquisition and data reduction. Analog data from the spectrometer is sent to the 360/50 via a subsidiary computer, the IBM 1800, at a rate determined by the user. A 16-bit analog-to-digital converter converts the analog data to 10,000 digital values per scan for use in the 360. Processed data is displayed on the spectrometers by the reverse process.

The software for the system was designed for the following applications:

(a) correction of spectra for baseline drift and systematic base-

Service Project Descriptions (cont'd.)

line irregularities,
(b) calculation of relative concentrations of paramagnetic species in the sample (value of the double integral),
(c) normalization of different spectra to the same relative concentrations,
(d) simulation of complex spectra by appropriate addition of composite spectra,
(e) output of computer-calculated spectra to the EPR recorder for comparison with experimental spectra, and
(f) long term storage of and ready access to spectra.

Research Projects Involving Computing Capability

(1) Studies of the protein hemoglobin have led to a model which accounts for the binding of oxygen to normal human hemoglobin as well as the abnormal binding to mutant hemoglobins. Continued study of abnormal hemoglobins is in progress.

Many of the observations which led to the model resulted from accurate measurement of small deviations among experimental spectra. Both normalization of spectra and spectral addition have been used in this project. Many small programs have also been used to analyze data points (least squares, etc.).

(2) Investigation of the structure of biological membranes has led to characterization of a wide range of motions that contribute to the characteristic fluidity of such membranes. We are making quantitative measurements of the extent of fluid regions in membranes and of the rates of motion of membrane components. The studies are directed toward an understanding of such problems as virus attack on cell membranes, biosynthesis of membranes, and surface properties of transformed tumor cells.

ACME is used to normalize spectra so that differences between two states of a membrane may be determined. Also, many details of membrane motion have been deduced from theoretical analysis (performed on ACME) of the line shapes of the magnetic resonance spectra. For example, a set of reference spectra have been added, in proportions dictated by solutions to the diffusion equation, in order to simulate a series of experimental spectra which are dependent on the rate of lateral diffusion of membrane components. The observed rapid lateral diffusion of membrane components has important biological implications in such areas as membrane biogenesis and structural arrangement of membrane components.

(3) Electrochemical potentials are an essential feature of living cells. We are developing "molecular indicators" of both trans-membrane potentials and localized surface potentials in membranes. In these studies, we design spin labels so that their spectra depend on whether the label is outside or inside the membrane, or inside of the membrane-enclosed volume. In general, the spectra of the two species of spin labels are overlapping and must be separated for quantitative analysis. A general procedure is to use ACME to calculate the total integrated area of both spectra and then compare

Service Project Descriptions (cont'd.)

this with the measured height of some portion of the composite resonance spectra.

Investigator: M. Lexie Nall
Dept. of Dermatology
Project Began April 1969

Project: L_NALL. PSORIASI
Non-Realtime

The computer is used to perform calculations in connection with a study of the genetics of psoriasis. A questionnaire requesting information on presence or absence of the disease in relatives was sent to almost 700 psoriasis sufferers and to 100 controls. A statistically significant familial concentration of the disease has been demonstrated which, together with twin studies, supports the concept that hereditary factors contribute to the etiology of psoriasis.

Pedigree analysis and frequencies of psoriasis among siblings of sufferers were not consistent with inheritance of genetic differences at a single autosomal or x-linked locus, even with decreased penetrance due to delayed age of onset. These findings, plus further analysis, suggested that psoriasis is determined by multifactorial inheritance.

Application of the twin method to this study is still in process. The sample of monozygotic and dizygotic twins (one or both members affected) was drawn from the United States.

The questionnaire used in this study has been translated into several languages. An international information exchange and coordination center is being set up in the Department of Dermatology.

Investigator: John Petralli
Stanford Univ. Hospital Clinical
Lab. - Infectious Disease
Project Began January 1969

Project: J_PETRAL. MED_DATA
J_PETRAL. INFCON
J_PETRAL. PROGRESS
Non-Realtime

Antibiotic-sensitivity testing gives physicians important information about treatment of specific infections. To improve the quality of antibiotic-sensitivity data (high potency single disc method) and to guide the interpretation of results and antibiotic selection, a computer program has been developed. Clinical information and zone sizes are entered into the ACME computer each day. As the information is given to the computer, the quality-control program immediately detects and challenges unusual results and directs the laboratory technicians to appropriate restudy of the organism in question. This system converts zone sizes to resistant, intermediate, or sensitive and prints final reports from its memory. These final results are generated three days to eight weeks after the specimen enters the lab. Reports for "routine" specimens are printed for distribution to the nursing units. Antibiotic sensitivity test

Service Project Descriptions (cont'd.)

results are compared to previous results and unusual values are flagged for further study before release to the physician. Results which pass this screening are interpreted for the physician. Previous results are analyzed every six months to allow updating of acceptable criteria and to provide the fellows and residents of Infectious Diseases with patterns of antibiotic susceptibility for approximately fifty organisms. The results for rare organisms are accumulated until sufficient data is present to include them in the daily quality control program.

Decreased potency of an antibiotic disc is detected by comparison of periodically determined mean zone sizes. Limits of confidence of a single reading are established by review of zone sizes observed with a standard organism tested on different occasions.

Knowledge of antibiotic sensitivities of organisms isolated from a specific site such as blood or urine will help to guide the selection of antibiotics before specific sensitivities are known. Such information is of value in selection of antibiotics in treating rarely encountered organisms with less well-known sensitivity patterns or in selection of alternate antibiotics when the first choice drug is hazardous. Yearly comparison of antibiotic sensitivity patterns obtained will give information about major trends and suggest appropriate changes in treatment of various infections.

Currently the project is testing the feasibility of automatically generating patient charges from the specimen identification data entered into ACME. This would hopefully decrease the paperwork for the lab personnel, facilitate data control and practically eliminate keypunching from charge slips. This also involves automatic routing of charges, depending on whether the patient made an in-house, clinic, or other outpatient visit.

There are plans to use ACME to provide physicians with preliminary results on a daily basis. Such a system would be adaptable to a hospital information system to provide instant preliminary and final results at nursing units as they are generated. This system should be running on a small scale within the near future.

Another plan involves using ACME to study the possibility of routinely identifying bacteria with gas chromatography.

This summer we will begin parallel testing of an automated sensitivity testing instrument for approximately four months. The machine will provide sensitivity results twenty hours sooner than conventional methods.

In addition to improving the accuracy of laboratory results for the benefit of patients, the computer has proved valuable in checking the work of laboratory technicians and students in training.

TRAINING PROJECTS

Investigator: James Calvert
Medical Student
Project Began November 1969

Project: J_CALVER. TEXT
Non-Realtime

The computer is used for calculations involving the economics of investment in biomedical research. Given some fraction of the gross national product as appropriate for the total national expenditure on health, national investment policy can be made more explicit and rational by considering for each major disease category:

(1) medical care costs and lost income per year,

(2) yearly probability of premature death or continued disability,

(3) fraction of the health budget allocated to research,

(4) discount (interest) rate for patient lives saved or improved,

(5) the maximum number of years allowed to complete cure or prevention of the particular disease.

A second study investigates the economics of effectiveness and efficiency in patient care. Effective patient care simultaneously focuses on the patient's visit, the current illness, the patient's year, and the patient's lifetime. Schedules for effective care are integrated by a simultaneous analysis of policies relating investments of professionals and facilities to benefits of patient care at each of the four time foci. Optimal schedules can then be derived for the care of individual patients within the national population by a weighting matrix of investment policies.

Efficient utilization of invested professionals and facilities is markedly influenced by such human capital factors as:

(1) degree of specialization and rate of ongoing improvement,

(2) flexibility of allocation, and

(3) overall state of the technical art.

Investigator: Glenn Funk
Medical Student
Project Began June 1971

Project: GAFUNK. RHINO
Non-Realtime

The intent of this project is to study rhinovirus defectiveness from three approaches:

(1) an attempt to derive a subgenomic "defective interfering" (DI) rhinovirion by rapid passage at high multiplicity of infection.

Training Project Descriptions (cont'd)

(2) study of the kinetics of viral RNA production at permissive and non-permissive temperatures, and

(3) study of the intracellular development of rhinovirions under both temperature conditions using an electron microscope.

In addition, an attempt will be made to determine a particle-to-PFU-ratio as an indicator of the degree of defectiveness of a viral suspension.

Investigator: Rodney Levine
Medical Student
Project Began December 1968

Project: RLLEVINE. CPS
Non-Realtime

The project was undertaken to clarify some of the mechanisms of pyrimidine synthesis in mammals, and the relationship of that synthesis to the control of cellular proliferation. The computer is used for data analysis and statistical evaluation. It greatly accelerates the pace of the experiments.

As the work has progressed into an examination of enzyme kinetics, the computer has been used for theoretical curve fitting. Important properties of the enzyme system have been deduced, and theoretical equations have led to the conclusion that an allosteric enzyme is involved.

The computer has been an indispensable aid in calculation related to prediction of enzyme preparation behavior in a sucrose gradient centrifugation.

Investigator: D. Craig Miller
Medical Student
Project Began February 1972

Project: C_MILLER. CAB
Non-Realtime

This project is an attempt to define concrete risk/benefit guidelines for the new saphenous vein - coronary artery bypass surgery.

Method:

1. Collection of 15 significant pre-operative parameters on 400 patients who have undergone the surgery at Stanford.

2. Collection of follow-up clinical and angiographic data on as many of the 400 patients as possible.

3. Collection of 5 operative parameters.

4. Using computer and non-parametric multivariable biostatistical methods, attempt to find correlations among the parameters collected.

Training Project Descriptions (cont'd)

5. Report Stanford's results and formulate pre-operative risk/benefit guidelines from the above data.

6. Report on subpopulations of patients with unique pre-op or post-op courses.

Investigator: Larry Nestor
Medical Student
Project Began January 1970

Project: L_NESTOR. DIFFDX
Non-Realtime

This project has developed a program to aid in diagnosis. Its original purpose was to provide a teaching aid for students. The program would output differential diagnoses with probability-like values associated with them, in response to a given set of symptoms.

Clinical practitioners can also make use of the program in an effort to avoid overlooking an obscure diagnosis. By asking the program what other diseases can show a given set of symptoms, the number of missed diagnoses can be reduced.

Investigator: Marc Nuwer
Medical Student
Project Began February 1971

Project: MRNUWER. NEURON
Non-Realtime

The computer is used for modeling of neurons and groups of neurons. Arrays are constructed which simulate the temporal and spatial relationships of electrical activity on neuron surfaces, using an array for the soma, and a set of arrays for dendrites. In this manner, the interactions of "slow potential" gradients on neurons can be matched; inputs can interact with both spatial and temporal summation.

Plans have been formulated to order the modeling to fit the parameters of known neuron types (e.g. pyramidal cells, stellate cells, etc.).

Array values will be changed to simulate the properties of the neuron membranes in a way which will simulate learning and memory, principally as proposed in a holographic memory model.

Investigator: William Rosenthal
Medical Student
Project Began December 1968

Project: W_ROSENT. RESEARCH
Non-Realtime

This project investigates speech and language pathology and normal speech perception, utilizing studies of language-deviant children. ACME is used for

Training Project Descriptions (cont'd)

statistical data reduction of auditory processing of these children and for longitudinal study and follow-up.

The project includes research into the effectiveness of stuttering therapy, speech and auditory perception in aphasic children, and normal speech perception in adults and children.

VIII. UTILIZATION DATA

A. Interpreting Utilization Charts

The terms used to discuss ACME utilization involve charging units and categories of users.

1. Charging Units

Last year, the computer service charge units were:

page minutes
terminal connect time
blocks of disk storage
terminal service charge

In April, 1972, our rate structure was revised and charge units for batch execution, CPU time slices, and tape mounts were added. However, due to their recent incorporation in the rate structure, no data is included for them.

A pageminute is defined as occupancy of 4096 bytes of core for one minute. Terminal connect time is the total number of minutes that a terminal is connected to the system in a logged-on condition. A block of disk storage is a fixed length block of 2000 bytes of 2314-type disk storage. The terminal service charge covers monthly terminal rent plus other services offered by the ACME staff. This service charge is handled by the University independent of the ACME grant.

2. User Categories

This table shows the category identifier, rate, and definition of each user category. The rate charged per pageminute varies by user categories and some categories are subsidized 100% by the ACME Grant. An asterisk next to the category identifier (*4) designates those so subsidized. All other categories are paying. There is a distinction between real-time and non-realtime users. Realtime users use the 1800 processor or 2701 data adapter for data collection or process control functions.

PAGE-MINUTE CHARGE TABLE

	Category	cents/pageminute Pre-April,72	Post-April,72
1.	Realtime User - Sponsored Research	.50	1.00
2.	Non-Realtime User - Sponsored Research	1.00	1.70
3.	Non-Stanford Medical	2.00	2.50
*4.	Medical Students	1.00	2.00
*5.	Realtime User - Core Research	.50	2.00
*6.	Non-Realtime User - Core Research	1.00	2.00
*7.	ACME Staff	1.00	2.00
8.	Hospital Data Processing	1.25	1.70
9.	Non-Medical - Stanford and Non-Stanford	2.50	2.00
*10.	Realtime - Pilot and Pending Proposal	.50	2.00
*11.	Non-Realtime - Pilot and Pending Proposal	1.00	2.00
*12.	Realtime - Extended Non-Funded	.50	2.00
*13.	Non-Realtime - Extended Non-Funded	1.00	2.00
16.	Negotiated Rates - Combination of Core Research and Medical Administration	.25	1.20

*No cash charges, i.e., absorbed by the ACME project budget.

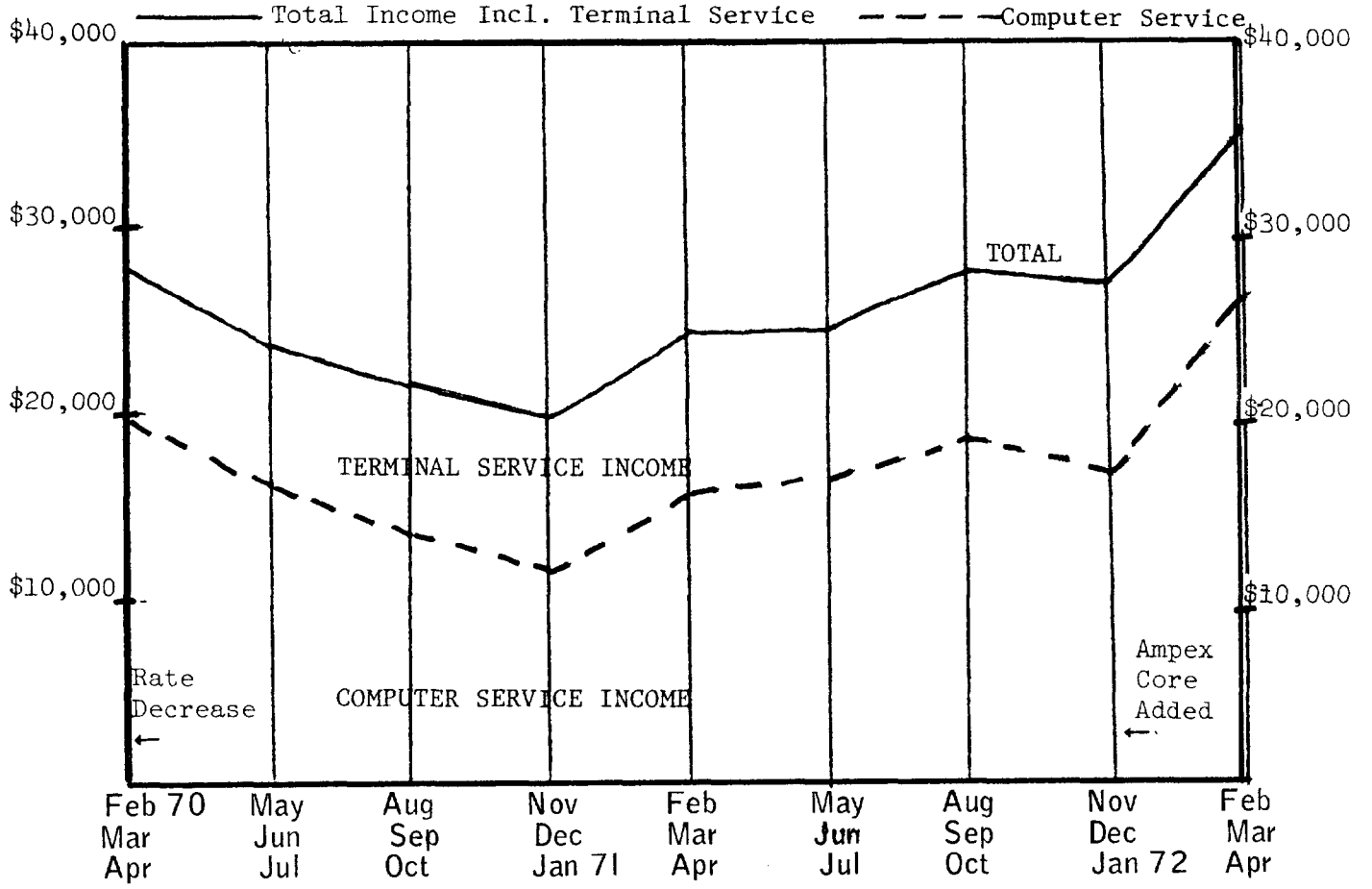
The four graphs in Section C show utilization since February, 1970 by user-supplied income, pageminutes of use, block storage, and number of terminal connect time hours. An additional table in Section C summarizes ACME utilization by Department. Section D summarizes computer resource usage by charge category and primary investigator.

B. Patterns of Use

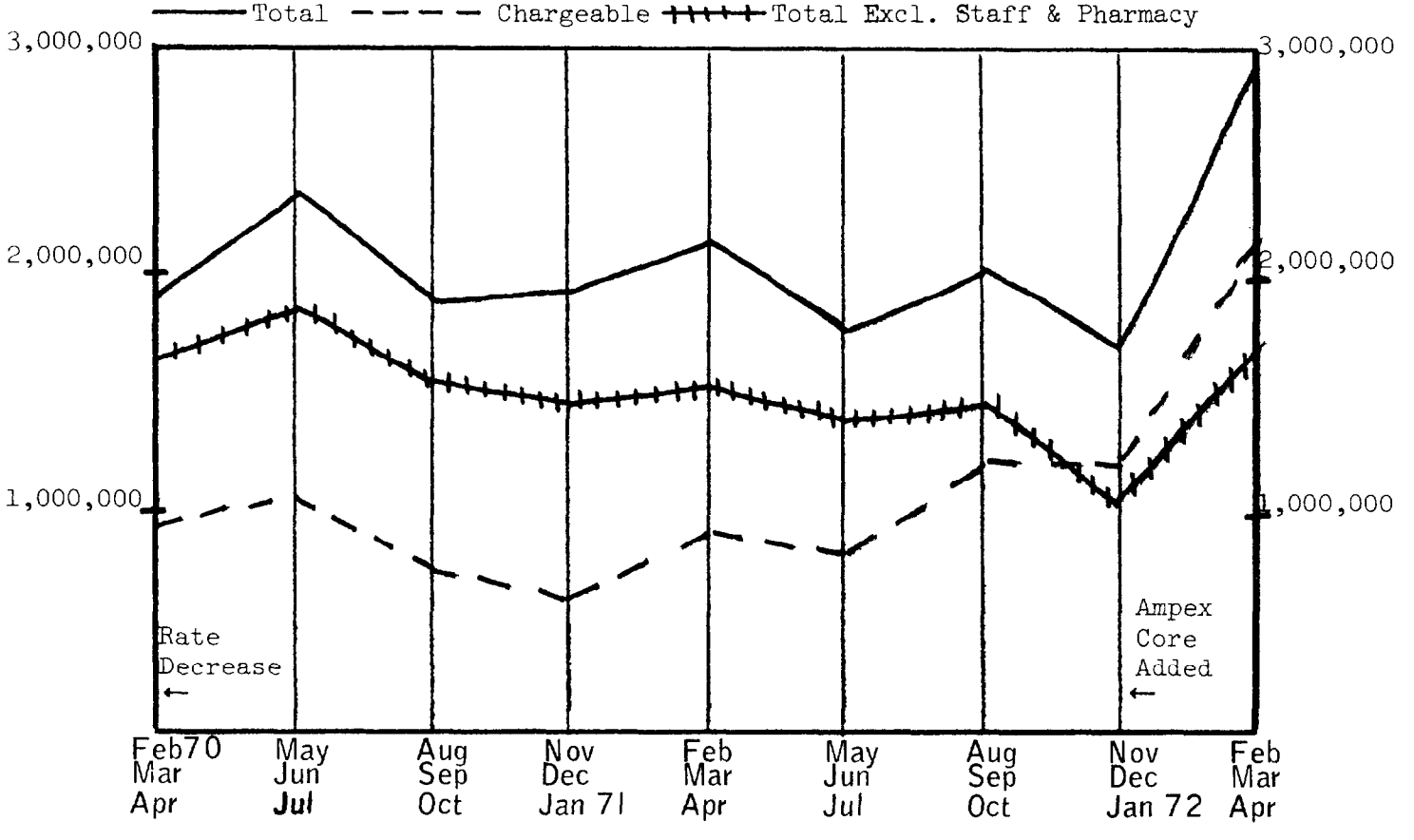
During fiscal year 1972, a noticeable shift has occurred from a preponderance of program development to execution. Approximately two years ago, it was normal to find 50% of logged-on users in execution with another 50% performing data entry functions or program development. One year ago, approximately 2/3 of those logged-on to the system were found to be in execution during normal daytime hours. More recently it appears that 75% of the users logged-on to the system are in program execution. The effect of this trend is that more cycles per user hour are absorbed than was the case two years ago. It also indicates that a certain amount of work performed on the system is now more or less routine or operates in a "production" mode. Much of this so-called production-type work is used to support research in the Medical Center. Examples of this are the realtime data collection from spectrometers and the data collection phase of the Drug Interaction Program.

During the past year, approximately 75%-85% of the available disk storage for users has been used. Frequently we have run out of space on individual packs during the normal operating hours. This has caused considerable inconvenience to all users, especially those who attempt to create very large files. Next month a number of data compression routines will be made available to all users. These routines will permit a considerable reduction in the amount of space used for individual files. We expect that our users will quickly adopt these techniques to reduce their disk storage charges.

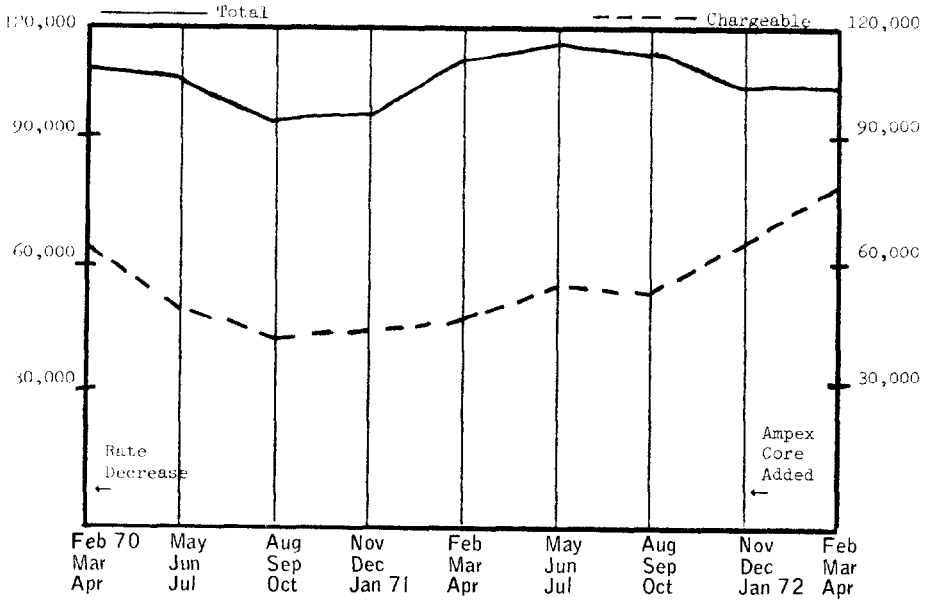
INCOME



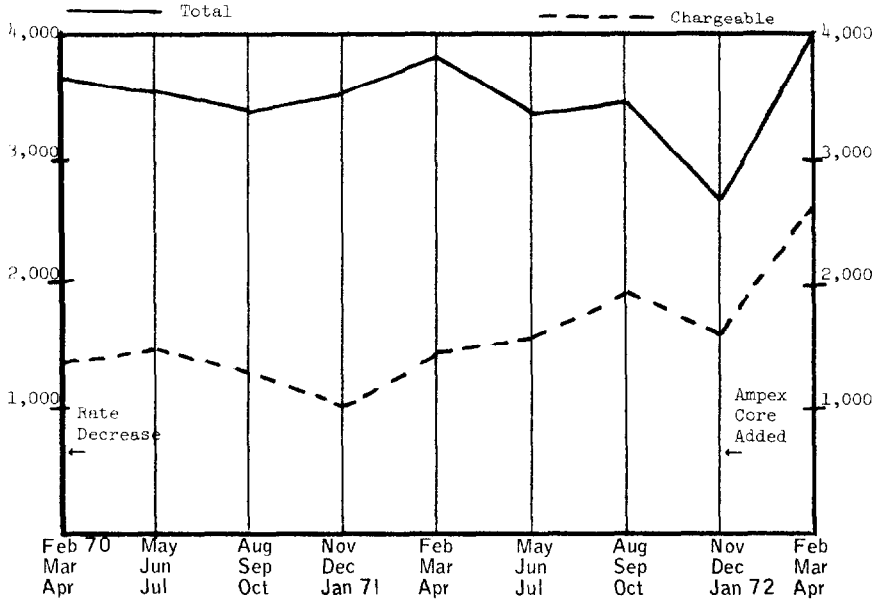
PAGEMINUTES



BLOCK STORAGE



TERMINAL HOURS



ACME UTILIZATION BY DEPARTMENT
Nine-Month Period - August 1971-April 1972

Department/Division	# of Terminals	PAGEMINUTES students	PAGEMINUTES non-chargeable	PAGEMINUTES chargeable	BLOCKS students	BLOCKS non-chargeable	BLOCKS chargeable	TOTAL CHARGE students	TOTAL CHARGE non-chargeable	TOTAL CHARGE chargeable	
MEDICAL SCHOOL											
Anesthesia	1.58	206,364	63,511	220,697	11,206	278	41,813	$3,184.24	$ 345.34	$6,222.87	
Biochemistry	1.00	23,428		88,402	538		3,885	288.08		1,272.52	
Comm and Prev Med				-0-			4			.40	
Biostatistics	.25	1,456		99,128	1,261		8,976	140.66		1,888.88	$ 1,889.28
Dermatology				1,199			1,534			165.39	
Genetics	4.00	176,282	221,019	1,837,843	19,580	32,222	57,677	3,720.82	5,417.69	19,185.78	
Gyn/Ob				32,373			3,287			652.43	
Medical Microbiology	1.00	21,113		308,022	1,053		17,035	316.43		4,783.72	
Medicine	1.00			278,457			22,668			5,051.37	
Cardiology		43,010			6,540			1,084.10			
Clinical Pharmacology	2.00		541,390	357,723		39,732	39,519		9,387.10	7,529.13	
Gastroenterology				6,628			508			117.08	
Hematology				221,618			7,726			2,988.78	$21,385.78
Immunology				29,053			133			303.83	
Infectious Diseases		20,585		3,536	1,408		1,812	346.65		216.56	
Endocrin & Metab Dis	3.00	22,318		410,063	1,053		10,784	328.48		5,179.03	
Oncology		3,540			1,217			157.10			
Respiratory Medicine		4,212			152			57.32			
Neurology		-0-		167,710	39		2,034	3.90		1,041.94	
Pathology	1.00	2,456		277,023	402		6,550	64.76		2,086.74	
Pediatrics		57,234		180,190	9,247		31,470	1,497.04		4,948.90	
Pharmacology	1.00		-0-	208,538		429	5,786		42.90	2,663.98	
Physiology		20,580			672			273.00			
Psychiatry	2.00	100,467	52,712	211,356	26,999	10,793	12,902	3,704.57	1,490.21	3,226.00	
Radiology	1.00			327,714			8,880			4,165.14	
Diagnostic Radiology	1.00	60,469		136,984	5,445		10,655	1,149.19		1,750.41	
Nuclear Medicine	1.00	6,407		155,006	640		2,563	128.07		1,149.40	$15,789.55
Radiation Therapy	.50			633,942			17,304			8,069.82	
Radiobiology	1.00			56,788			869			654.78	
Surgery				30,653			4,209			727.43	
Cardiovascular		22,329	-0-	120,497	1,977	12	9,202	420.99	1.20	1,522.64	
Ophthalmology				14,900			40			153.00	
Otolaryngology		7,480	899	-0-	598	36	18	134.60	12.59	1.80	$ 3,227.95
Urology	.67		146,802	130,450		1,351	1,265		869.08	823.08	
Admissions Committee				94,529			10,771			2,022.39	
Fleischmann Labs				148,025			1,495			1,629.75	
Joint Teaching & Research	1.50			126,782			13,667			2,491.04	
Regional Medical Program	1.00			139,759			12,813			2,678.89	
MEDICAL SCHOOL TOTAL	25.50	799,730	1,026,333	7,055,588	90,027	84,853	369,854	$17,000.00	$17,566.11	$97,364.90	

Department/Division	# of Terminals	PAGEMINUTES students	PAGEMINUTES non-chargeable	PAGEMINUTES chargeable	BLOCKS students	BLOCKS non-chargeable	BLOCKS chargeable	TOTAL CHARGE students	TOTAL CHARGE non-chargeable	TOTAL CHARGE chargeable
HOSPITAL										
Cardiology	1.00									
Clin Lab-Immunology				1,432			14			$ 15.72
Clin Lab-Infec Diseases	1.00			835,795			27,898			11,147.75
Clin Lab-Pathology	3.00			1,000,064			7,163			5,935.00
Data Processing	1.00			788			36			13.44
Pharmacy	1.00		-0-	3,358,931		2	30,317		$ .20	11,429.02
HOSPITAL TOTAL	7.00		-0-	5,197,010		2	65,428		$ .20	$28,540.93
SUH CLINICS	1.00			203,599			16,793			$2,809.75
OTHER CLINICS AND HOSP	1.00			385,256			4,896			$6,975.80
CAMPUS										
Aero and Astro				4,232			1,178			$ 223.58
Biosciences	1.00	-0-		406,973	16		4,590	$ 1.60		2,493.81
Chemistry	1.00	9	272,084	893,354	389	17,443	46,824	38.99	3,272.56	15,141.67
Civil Engineering		-0-			144			14.40		
Communications				17,640			703			511.29
Computer Science*				2,044,603			91,706			20,195.92
Grad School of Business				-0-			9			.90
Law				6,525			1,327			295.81
Math	1.00			13,982			45			144.32
Physics				75,255			3,233			1,452.01
Psychology				27,768			871			698.58
Statistics	.50	2,942		8,268	147		473	44.12		145.38
CAMPUS TOTAL	7.50	2,951	272,084	3,408,600	696	17,443	150,959	$ 99.11	$3,272.56	$41,303.27
UNKNOWN SCRATCH**		288,839			273			$2,915.69		
OTHER (SLAC, SEL, Carnegie, etc.)				220,639			12,694			$5,231.54
USER TOTALS	42.00	1,091,520	1,298,417	16,550,692	90,996	102,298	620,624	$20,014.80	$20,838.87	$182,226.19
ACME	11.00		5,565,832***			202,525			75,910.43	
GRAND TOTALS	53.00	1,091,520	6,864,249	16,550,692	90,996	304,823	620,624	$20,014.80	$96,749.30	$182,226.19

Terminal distribution is that of April 1972. One terminal (A86), owned by the Genetics Dept., is listed as an ACME terminal, because it is located in the Machine Room.

*Primarily the DENDRAL project, serving the Departments of Genetics, Chemistry, and Computer Science.

**Unknown users, mostly medical students.

***Of this total, 3,292,566 pageminutes were used by Operations to run the system.

PAGEMINUTES GRAND TOTAL: 24,506,461
BLOCKS GRAND TOTAL: 1,016,433

SUMMARY OF COMPUTER RESOURCE USAGE

April 17, 1971 - April 16, 1972

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Category 1 Realtime Sponsored Research (CHARGEABLE)									
Bacon, Virginia	Genetics	GAME. Computer control of Finnigan 1015 quadrupole mass spectrometer.	NGR004	NASA	$240,000.00	C	786.3	918.487	20.553
Constantinou, Christos	Urology	UROL. Investigation of upper urinary tract physiology.	AM05513	NIH	71,598.00	C	180.5	94.513	0.930
DeGrazia, Joseph	Nuclear Medicine	RADIOREN. Development of radioisotope techniques for the evaluation of differential kidney function.	--	Public Health Hosp. S.F.	--	S	6.4	2.767	1.759
DeGrazia, Joseph	Nuclear Medicine	CLINIGAS. Coordination of computer and metabolic gas analyser.	--	Univ Funds	--	S	189.8	109.244	1.859
Dong, Eugene	Cardiovascular Surgery	LAB. Study of the principles of mammalian heart rate control, emphasis on sino-atrial node.	HE08696	NIH	117,708.00	C	133.8	109.499	8.725
Dong, Eugene	Cardiovascular Surgery	PATIENT. Examination of cardiac surgery patient data.	--	Clinic Budget	--	S	335.8	235.456	22.371
Dong, Eugene	Cardiovascular Surgery	CLIN. General data reduction.	HE13108	NIH	243,003.00	S	40.5	15.976	3.140
Gersch, Will	Neurology	SYNTHESI. Application of time series methods to problems in neurophysiology and medicine.	--	Univ Funds	--	S	297.3	183.199	2.741
Glick, David	Pathology	LASER. Laser microprobe analytical system for elemental analysis of microscopic biological samples.	GM16181	NIH	112,446.00	S	481.5	280.334	6.687
Gold, Jerome	Diagnostic Radiology	SWALLOW. Esophageal blood flow studies.	GM01707	NIH	119,608.00	C	190.3	108.434	10.265
Green, Paul	Biosciences	AVENA. Kinetic analysis of hormones affecting the growth process.	GB28667	NSF	90,000.00	S	142.8	156.047	1.699
Hanawalt, Philip	Biosciences	TRI CARB. Use of radioisotope tracers to study molecular biology of cell growth and repair of damage to genetic material.	GM00365	NIH	44,096.00	S	333.7	207.484	3.676
Harrison, Donald	Cardiology	CATH LAB. On-line cardiac catheterization data analysis; recognition of abnormal EKG complexes.	HE05709	NIH	63,274.00	C	116.2	40.644	16.137
Kennedy, Donald	Biosciences	NERVOUS. Analysis of neurophysiological data with aim of understanding the nervous system.	NS09744	NIH	62,660.00	S	3.8	1.191	0.025
Kopell, Bert	Psychiatry	ICON. Study of AER's (Averaged Evoked Responses) in EEG's.	MH19918	NIH	74,666.00	S	20.2	4.948	0.261
Lederberg, Joshua	Genetics	EXPT. Use of a Packard liquid scintillation counter to analyze the incorporation of radiolabeled amino acids into brain.	GM00295	NIH	139,457.00	S	137.4	93.816	3.484
Mazze, Richard	Anesthesia	RENAL. Study of renal failure following general anesthesia.	--	PAVA Hosp	--	S	195.3	87.775	2.085

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Category 1 (cont'd.)	Realtime, Sponsored Research (CHARGEABLE)								
Pauling, Linus	Chemistry	MENTLRES. Research on the molecular basis of mental disease, involving gas chromatography.	MH18149	NIH	$139,812.00	S	817.3	468.472	47.003
Reynolds, Walt	Genetics	SOOT. Automation of mass spectrometer instrumentation systems.	NGR004	NASA	240,000.00	S	22.6	5.425	3.074
Reynolds, Walt	Genetics	DENDRAL. Mass spectra analysis and interpretation.	RR00612	NIH	295,125.00	C	118.2	45.794	6.812
Rindfleisch, Thomas	Genetics	DENDRAL. Mass spectra analysis and interpretation.	RR00612	NIH	295,125.00	C	125.7	73.279	1.225
Ross, Robert	Chemistry	DENDRAL. Mass spectra analysis and interpretation.	RR00612	NIH	295,125.00	C	841.0	1050.203	47.988
Roth, Walton	Psychiatry	AER. Research into computer processing of EEG data.	MH19918	NIH	74,666.00	S	27.2	10.037	0.201
Smith, Norman	Anesthesia	BABCONS. Cardiovascular data file storage; statistical analysis.	GM12527	NIH	536,448.00	S	0.0	0.0	0.010
Smith, Norman	Anesthesia	MAC. Calculation of human cardiovascular data.	GM12527	NIH	536,448.00	S	0.0	0.0	0.340
Smythe, Harvey	Psychiatry	SLEEP. Analysis of data from all-night sleep EEG's.	MH19071	NIH	58,689.00	S	63.1	17.226	0.515
Stefik, Mark	Genetics	DENDRAL. Mass spectra analysis and interpretation.	RR00612	NIH	295,125.00	C	566.4	363.554	16.954
Stillman, Robert	Chemistry	DENDRAL. Mass spectra analysis and interpretation.	RR00612	NIH	295,125.00	C	172.7	111.690	8.826
Sussman, Howard	SUH - Clin. Lab. - Pathology	LAB_PAT/LABSYSO. Development of an automated data processing system for the clinical pathology laboratory of Stanford Hospital.	--	Hosp Funds	--	C	1280.4	819.292	7.347
Swanson, George	Anesthesia	RESPRE. Investigation of neural mechanisms which sustain ventilation in absence of chemical stimulation.	GM12527	NIH	536,448.00	S	0.6	0.122	0.009
Tatton, William	Biosciences	DPERKEL. Characterization of neural circuits underlying behavior and sensory information processing in mammals and invertebrates.	NS09744	NIH	62,660.00	S	90.6	47.656	0.282
Tucker, Robert	Genetics	MS. Control of Mass spectrometer - GLC apparatus.	NGR004	NASA	240,000.00	S	0.0	0.0	1.892
Wilson, Donald	Biosciences	NERVOUS. Analysis of neurophysiological data.	NS02944	NIH	56,690.00	S	0.0	0.0	0.008
					SUB-TOTAL		7717.4	5662.564	248.881

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Category 2 (cont'd.)	Non-Realtime, Sponsored Research (CHARGEABLE)								
Brutlag, Douglas	Biochemistry	ULTRA. Studies of the role of divalent metal ions in the reaction mechanism of the enzyme DNA polymerase.	GM07581	NIH	$299,344.00	S	49.7	15.566	1.422
Buchanan, Bruce	Computer Science	STAT. Statistical demonstration programs for a course in biostatistics.	GM01922	NIH	269,243.00	T	91.0	30.443	0.224
Butler, Edmond	Urology	UROSTATS. Urology operative statistics information and retrieval program.	--	Univ Funds	--	S	12.0	15.050	3.759
Cady, Paxton	Psychiatry	THYROID. Study of the relationship between stress and a partial genetic defect in thyroid function.	--	Personal Funds	--	S	0.0	0.0	6.106
Cann, Howard	Pediatrics	GUAT. Population genetics studies of Mayan Indians of Guatemala.	GM15593	NIH	37,598.00	S	473.8	176.387	34.735
Cavalli, Luca	Genetics	KEN. Analysis of genetic models of disease; simulation programs.	AT (04-3)-326-PA-33 .	AEC	30,000.00	S	18.5	5.230	0.115
Cavalli, Luca	Genetics	LAURA. Data analysis on population genetics.	AT (04-3)-326-PA-33	AEC	30,000.00	S	145.7	81.100	1.062
Cavalli, Luca	Genetics	MARK. Analysis of pygmy anthropometric and demographic data; simulation of genetic drift and selection models.	AT (04-3)-326-PA-33	AEC	30,000.00	S	2.0	0.422	0.020
Cavalli, Luca	Genetics	PAVIA. Population genetics: evolutionary rate, patterns of inheritance in behavioral traits, analysis of record linkage and pedigree information.	AT (04-3)-326-PA-33	AEC	30,000.00	S	367.4	194.046	2.371
Cavalli, Luca	Genetics	JUDY. Text editing for population genetics research.	AT (04-3)-326-PA-33	AEC	30,000.00	S	54.8	23.067	0.982
Chan, Piu-Chu	Radiobiology	GROWTH. Simulation of cellular population growth pattern.	CA04542	NIH	30,838.00	S	36.4	13.302	0.252
Chase, Robert	Surgery	CPGFAC. Evaluation of facial growth in cleft palate children and determination of velopharyngeal competence.	DE02803	NIH	30,160.00	S	0.0	0.0	0.516
Clayton, Raymond	Psychiatry	SEXERAIN. Effect of steroids and hormones on RNA activity of the brain.	HD00801	NIH	54,084.00	S	0.0	0.0	2.460
Cohen, Stan	Clinical Pharmacology	DRUGALRT. Computerized system to warn of interactions of drugs administered to patients.	HS00739	NIH	278,303.00	C	467.6	287.556	39.519
Conner, James	Comm & Prev Med	HEALTH. Statistical analysis of health training study.	AH00695	NIH	72,864.00	S	22.9	4.814	0.309
Conner, Robert	Psychiatry	RATRACE. Relation of neuroendocrine function to behavior.	HD02881	NIH	203,864.00	S	99.5	63.864	0.887
Cooper, John	Psychiatry	SEXDIFF. Investigation of biochemical correlates of neonatal sexual differentiation in rats.	HD00801	NIH	54,084.00	S	9.5	5.912	0.307

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Category 2 (cont'd.)	Non-Realtime,	Sponsored Research (CHARGEABLE)							
Daly, Virginia	SUH - Immunol Lab	CH50. Establishment of normal values for human serum total complement levels and clinical tests on patients to determine their level.	--	Hosp Funds	$ --	S	2.7	1.027	0.014
Dilley, Jeanette	Immunology	CYTOTOX. Study of murine transplantation antigens on various tissues; description of biological and biochemical characteristics of the soluble transplantations from these tissues.	AM05425	NIH	87,336.00	S	40.1	27.254	0.127
Dirks, Judie	Psychiatry	PORNO. Analysis of normal subjects' average evoked responses to pictures of nudes.	MH19918	NIH	74,666.00	S	29.9	9.840	1.069
Doering, Charles	Psychiatry	DESMOLAS. Investigation of the biochemical connection between hormones and stress.	HD00801	NIH	54,084.00	S	12.5	3.642	0.775
Drake, Karl	Psychiatry	NEUROPSY. Analysis of neurophysiological and neurobehavioral data, including power spectrum analysis of EEG's.	MH12970	NIH	218,539.00	S	6.8	1.432	0.044
Eddy, David	Engineering	MARKOV. Use of a Markov model of coronary artery disease for optimum treatment decision.	--	Univ Funds	--	S	22.6	18.637	0.121
Fletcher, Grant	Anesthesia	DIALYSIS. Statistical analysis of lab results of in vivo and in vitro studies of uptake, metabolism and elimination of sedative drugs.	--	Hartford Fdn.	65,000.00	S	1.5	0.323	0.044
Forrest, William	Anesthesia	DATA. Development of an inexpensive system of quality and quantity control of large amounts of clinical data.	DADA 17-70-C-0104	Army	15,000.00	S	0.1	0.018	4.792
Forrest, William	Anesthesia	SCHEDULE. Automation of monthly scheduling of doctors for "on call" duty.	--	Clinic Budget	--	S	29.4	24.737	2.086
Forrest, William	Anesthesia	SURGICAL. Maintenance of records on surgical operations; source of data for reports on these operations.	--	Univ Funds	--	S	77.2	31.433	2.88[illegible]
Forrest, William	Anesthesia	ANALGESI. Development of an inexpensive system of quality and quantity control of large amounts of clinical data.	GM12527	NIH	536,448.00	S	89.7	77.400	35.598
Fowkes, William	Regional Medical Program	ANALYSIS. Analysis of data from registry of stroke patients.	--	CCRMP	143,127.00	S	31.2	23.100	0.244
Fowkes, William	Regional Medical Program	STROKE. Development of a county wide registry for stroke patients in Santa Cruz County; development of a population base for study and analysis.	--	CCRMP	143,127.00	S	134.2	104.979	11.112
Friedland, Gerald	Diagnostic Radiology	SLINGFI. Determination of the action of the gastric sling fibers.	GM01707	NIH	119,608.00	S	9.4	5.038	0.796

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Category 2 (cont'd.)	Non-Realtime,	Sponsored Research (CHARGEABLE)							
Fries, James	Medicine	DATABANK. Establishment of a large clinical databank of time-oriented patient records; exploration of multiple uses of the stored information.	--	Arthritis Fdn.	$ 12,796.00	C	589.8	254.362	27.220
Goldstein, Avram	Pharmacology	OFFSTUFF. Study of methadone maintenance programs for heroin addicts.	MH18960	NIH	21,988.00	S	106.0	110.809	4.647
Goldstein, Avram	Pharmacology	NARCO. Mechanism of the action of narcotics and the fundamental aspects of narcotic addiction.	MH13963	NIH	183,208.00	S	35.7	10.670	0.874
Goldstein, Dora	Pharmacology	BARB. Establishment of essential parameters for enzyme kinetics in inhibition of flavin enzymes by barbituates.	MH13963	NIH	183,208.00	S	130.5	60.178	0.668
Grant, Scott	Ophthalmology	CORNEA. Simulation of light scattering by the cornea using electromagnetic theory.	EY00431	NIH	175,604.00	S	29.9	10.412	0.040
Greenberg, Peter	Hematology	CSFASSAY. Evaluation of factors regulating granulopoiesis in human disease states.	577	Amer Cancer Soc, Inc.	11,669.00	S	9.7	2.839	0.016
Guess, Harry	Mathematics	EVOL. Genetics research: model simulation using various values of mutation rate, population size and mutant fitness distribution.	GM10452	NIH	81,248.00	S	26.2	10.047	0.045
Hahn, George	Radiobiology	RADIATE. Simulation of kinetics of mammalian cell proliferation, design of theoretical dose scheduling for leukemia treatment.	CA04542	NIH	30,838.00	S	0.8	0.289	0.416
Herzenberg, Leonard	Gyn/Ob	STORE/LAB/PIGGY. Immunology, genetics and maternal-fetal immunologic relationships in the mouse.	HD01287	NIH	52,370.00	S	78.6	27.444	2.293
Hjelmeland, Larry	Computer Science	DENDRAL. Development of LISP programs for DENDRAL project.	RR00612	NIH	295,125.00	S	50.0	100.971	0.438
Hogness, David	Biochemistry	OREGON R. Analysis of DNA fragments from Drosophila melanogaster.	AM07535	NIH	84,425.00	S	15.9	4.991	0.694
Jazwinski, Stanislaw	Biochemistry	MEMBRANE. Characterization of membrane-bound phospholipase; data obtained from enzyme assays, multi-channel separations, etc.	GM07581	NIH	299,344.00	S	9.4	1.957	0.139
Jones, Stephen	Radiology	LYMPHOMA. Statistical study of various groups and sub-groups of non-Hodgkins lymphoma patients.	CA08122	NIH	253,471.00	S	124.9	104.596	0.621
Jovin, Thomas	Biochemistry	ARG. Data reduction and generation of systems for electrophonic separations based upon theoretical models.	GM07581	NIH	299,344.00	S	0.0	0.0	0.120
Kakihana, Ryoko	Psychiatry	ETHANOL. Data analysis for neuroendocrine research on hormones and stress.	MH14364	NIH	40,572.00	S	21.8	7.094	0.385

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Category 2 Non-Real time, Sponsored Research (CHARGEABLE)									
Aronow, Lewis	Pharmacology	LCELL. Laboratory calculation of mechanisms of anti-cancer drug action.	CA05672	NIH	$ 49,908.00	S	35.3	11.744	0.283
Assaykeen, Tatiana	Urology	RENIN. Study of renin secretion mechanisms.	AM13548	NIH	44,086.00	S	26.8	5.616	0.444
Atkinson, Martha	Med School Admissions Committee	FINANCE. Examination of Yale medical student loan system's applicability to Stanford.	--	Univ Funds	--	S	44.5	26.852	0.616
Atkinson, Martha	Med School Admissions Committee	FLYHIGH. Aid to Admissions Committee in selecting new medical school classes from applicants.	--	Univ Funds	--	S	89.5	58.370	10.775
Atkinson, Martha	Med School Admissions Committee	MATCHES. Matching of medical students clerkship requests with available positions.	--	Univ Funds	--	S	0.2	0.038	0.024
Axline, Stanton	Medicine	LYSOSOME. Analysis of kinetics of protein turnover by tissue culture cells.	AI10055	NIH	38,520.00	S	0.0	0.0	0.002
Bagshaw, Malcolm	Radiation Therapy	SUMMARY. Patient data storage and information retrieval; statistical programs relating to radiation dosimetry.	CA05838	NIH	1104,398.00	S	717.1	510.102	20.524
Baldwin, Robert	Biochemistry	OLIGOMER. Study of short DNA helices and their helix-forming properties.	AM04763	NIH	69,160.00	S	0.0	0.0	0.074
Bausek, Gerald	Radiation Therapy	HODPAT. Study of lymphomas: causes and treatment.	CA05838	NIH	1104,398.00	S	0.0	0.0	0.270
Belt, Donald	Otolaryngology	HSA. Hearing and vision screening: processing of results of tests administered to elementary school children.	--	Personal Funds	--	S	115.9	70.782	5.055
Berns, Robert	Computer Science	LISP. Development of LISP language for DENDRAL project.	RR00612	NIH	295,125.00	S	23.3	48.509	13.926
Biggs, Suzanne	Pharmacology	REGRESS. Analysis of membrane proteins.	GM00322	NIH	145,904.00	S	7.2	2.545	0.167
Bodmer, Walter	Genetics	POPGEN. Human white blood cells and population genetics.	GM14650	NIH	21,081.00	S	440.8	361.866	26.802
Brown, Byron	Anesthesia	BIOSTAT. Computations in support of Dept of Anesthesia research projects.	GM12527	NIH	536,448.00	S	25.1	7.480	7.835
Brown, Byron	Anesthesia	JOBST. Analysis of EKG data.	HE10202	NIH	162,430.00	S	147.8	66.214	5.283
Brown, Byron	Biostatistics	CONSULT. Biostatistical computations in support of many medical research projects.	RR05353	NIH	366,959.00	S	182.6	54.117	9.248
Brown, Byron	Biostatistics	CLASS. Classwork for course in biostatistics.	GM01922	NIH	269,243.00	T	73.7	25.499	1.111
Brown, Byron	Biostatistics	RESEARCH. Computations in support of development of new biostatistical techniques.	RR05353	NIH	366,959.00	S	76.6	29.315	2.553

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Category 2 (cont'd.	Non-Realtime,	Sponsored Research (CHARGEABLE)							
Kallman, Robert	Radiobiology	SURVIVAL. Analysis of data relating the survival of experimental tumor cells to the dose of irradiation received by the cells.	CA03353	NIH	$ 21,626.00	S	1.1	0.287	0.136
Kalman, Sumner	Pharmacology	DIGIMUNE. Routine calculation of daily assays of plasma, urine, and other biological fluids containing digoxin.	HE13618	NIH	35,959.00	S	19.3	7.445	0.081
Kendig, Joan	Anesthesia	RESPOT. Effects of drugs (anesthetic agents, muscle relaxants and catecholamines) on skeletal muscle-resting potential and ion distribution.	GM12527	NIH	536,448.00	S	17.2	4.426	0.193
Kessler, Seymour	Psychiatry	MATSPEED. Analysis of mating speed experiments.	MH14364	NIH	40,572.00	S	10.6	2.758	0.380
Kraemer, Helena	Psychiatry	PSYSTAT. Analysis of data from various psychiatric research projects.	--	Univ Funds	--	S	109.8	27.602	4.171
Kriss, Joseph	Nuclear Medicine	ASSAY. Studies on the pathogenesis of Graves' disease, the effects of X-ray therapy on thyroid function, and the pathogenesis of other endocrine disorders associated with autoimmunity.	AM07642	NIH	64,079.00	S	59.8	22.400	1.619
Kriss, Joseph	Nuclear Medicine	BLDVOL1. Calculation of plasma volume, blood volume, red cell mass, red cell life span, iron turnover and renal clearance in patients who receive radioactive tracer material.	AM07642	NIH	64,079.00	S	0.0	0.0	0.048
Laipis, Philip	Genetics	LIGASE. Reduction of data from experiments on sucrose and cesium chloride gradients in the ultracentrifuge.	GM14108	NIH	35,197.00	S	0.2	0.040	0.030
Lamb, Emmett	Gyn/Ob	EMPIRE. Calculation of relative potency and confidence limits of total gonadotropen activity of human urine extracts.	--	Univ Funds	--	S	30.1	9.969	2.028
Lederberg, Joshua	Genetics	GENLIB1. Statistical and miscellaneous other programs for use of the Genetics Department.	GM00295	NIH	139,457.00	S	0.0	0.0	0.004
Lehman, I. Robert	Biochemistry	LIGASE. Studies of the enzymatic mechanism of the DNA Ligase of E. coli.	GM06196	NIH	133,128.00	S	19.3	7.342	0.199
Leiderman, P. Herbert	Psychiatry	KENYA. Analysis of data collected in Kenya, relating the effect of social structure of primary family on infants' social attachments in the first year of life.	--	Grant Fdn.	8,000.00	S	41.8	13.717	1.470
Leiderman, P. Herbert	Psychiatry	PREMIE. Study of human maternal behavior relating the degree of interaction between mother and infant in the post-partum period to later maternal attachment and infant development.	MH20162	NIH	39,420.00	S	14.9	6.174	0.676

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Category 2 (cont'd.)	Non-Realtime,	Sponsored Research (CHARGEABLE)							
Lucas, Zoltan	Surgery	KIDTRANS. Tabulation of survival data for renal transplant patients.	--	Univ Funds	$ --	S	7.9	6.564	0.618
Luetscher, John	Endocrinology and Metab. Diseases	BLOOD PR. Secretion and metabolism of adrenal hormones; identification of curable forms of hypertension.	HE13817	NIH	53,119.00	S	190.2	56.778	4.635
Luzzatti, Luigi	Pediatrics	GRAGSON. Morphology of the late-replicating X Chromosome.	--	National Fdn.	30,000.00	S	4.5	1.336	0.745
Maffly, Roy	Endocrinology and Metab. Diseases	CO2. Sodium transport; predictive value of tests for blood urea nitrogen and decreased serum sodium concentration.	AM05678	NIH	51,776.00	S	46.4	16.734	0.362
Maffly, Roy	Endocrinology and Metab. Diseases	TEACH. Teaching programs for students and staff: evaluation of patients acid-base disorders; displayed on Beehive terminal and projected onto large screen for class use.	---	Univ Funds	--	T	199.7	118.653	1.837
McConnell, Harden	Chemistry	ABSORB. Paramagnetic resonance spectra research; hemoglobin mutations, fluidity of membranes, electrochemical potential of membranes.	GP26456	NSF	38,500.00	S	427.1	275.752	2.946
McDevitt, Hugh	Immunology	MARGALO. Calculation of the antigen-binding activity of antisera from mice immunized with various branched multichain synthetic polypeptide antigens.	AI07757	NIH	147,741.00	S	1.2	0.405	0.013
Melen, Robert	Electronics Lab	ISLCHROM. Development of a system of automatic classification of human chrosomes.	N0044	Navy	25,000.00	S	20.3	38.071	0.316
Melges, Frederick	Psychiatry	TEMPO. Study of psychotic processes; especially relating changes in temporal experience to psychopathological symptoms.	MH19918	NIH	74,666.00	S	38.6	9.883	2.419
Miller, Rupert	Statistics	THESES. Biostatistical computing by graduate students for theses or other educational use.	GM00025	NIH	85,388.00	T	17.3	4.589	0.235
Miller, Rupert	Statistics	COURSES. Computing done by staff in connection with the teaching of biostatistics.	GM00025	NIH	85,388.00	T	0.1	0.036	0.042
Minami, Roland	Surgery	RSP. Evaluation of respiratory studies as a measure of velopharyngeal incompetence, comparing it with age, cine-fluorographic results, operation, and time.	DE02803	NIH	30,160.00	S	11.5	4.392	0.032
Morris, Randall	Surgery	CTX. In vitro assay of transplantation immunity aimed at development of a superior immunosuppressive protocol.	GM01922	NIH	269,243.00	S	40.2	10.574	0.177
Nall, Lexie	Dermatology	PSORIASI. Psoriasis research.	--	Univ Funds	--	S	6.4	2.399	2.661

SUMMARY OF COMPUTER RESOURCE USAGE

April 17, 1971 - April 16, 1972

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INVESTIGATOR	DEPARTMENT/ INSTITUTION	PROJECT TITLE	DIRECT GRANT OR CONTRACT SUPPORT Identification Number	Agency	Current Annual Amt.	BRR Category*	AMOUNT OF USAGE - TIME SHARING COMPUTER Terminal Access Hours	Pageminutes (1) @ $ .01 per pageminute	Block Storage (2) (Block=2k bytes) @ $ .10 per block
Category 2 (cont'd.)	Non-Realtime, Sponsored Research (CHARGEABLE)								
Nelson, Thomas	Radiology	ADRENAL. Clinical cancer research.	GA08122	NIH	$253,471.00	S	0.0	0.0	0.306
Nye, William	Med. Microbiology	STRUCTUR. Statistical calculations and bibliography compilations in the field of immunochemistry.	AI00082	NIH	146,576.00	S	72.0	19.264	0.802
Ordal, John	Immunology	ALGERNON. Calculation of antigen-binding activity of antisera from mice immunized with various branched multichain synthetic polypeptide antigens.	GM01922	NIH	269,243.00	S	23.7	5.689	0.041
Ostrem, Dennis	Biochemistry	GLYCYLRS. Enzyme research on glycl-TRNA: kinetics of subunit association, ultracentrifuge experiments, and amino acid analysis.	GM13235	NIH	166,947.00	S	38.2	26.638	0.646
Payne, Rose	Hematology	SERNAL. Extension and classification of leukocyte and/or tissue antigens by serologic and genetic analysis of specific human antisera.	HE03365	NIH	78,049.00	S	226.5	352.708	21.063
Petralli, John	SUH - Cli Lab. Inf. Dis.	MED DATA. Computer method for improvement of antibiotic sensitivity data and guidance in therapy.	--	Hosp. Funds	--	S	1929.3	755.325	31.560
Petralli, John	SUH - Cli Lab. Inf. Dis.	INFCON. Infection control: data on isolation patients.	--	Hosp. Funds	--	S	51.5	12.161	0.564
Petralli, John	SUH - Cli Lab. Inf. Dis.	PROGRESS. Program development for Infectious Disease Lab computing.	--	Hosp. Funds	--	S	64.4	19.313	0.550
Pfendt, Eva	Med Microbiology	CANVIRTU. In vitro studies of human tumors.	NCI-69-2053	NIH	179,810.00	S	4.8	1.196	0.113
Rapp, Wolfgang	Gastroenterology	OUDINLIN. Immunological determination of the gastric antigenic esterase VI A in gastric juices of patients with gastric diseases.	AM06971	NIH	92,644.00	S	0.0	0.0	0.252
Reaven, Gerald	Endocrinology and Metab. Disease	PAT DATA. Risk factors in coronary heart disease; modeling of metabolite action important in diabetes mellitus and atherosclerosis; inpatient data on metabolic disorders; participation in nationwide clinical trial of "lipid hypothesis".	71-2161	NIH	409,873.00	C	573.1	234.050	6.396
Reaven, Gerald	Endocrinology and Metab. Disease	DISPLAY. Graphics display program and modeling programs for the research detailed above.	HE08506	NIH	72,990.00	C	118.5	107.979	2.351
Reitan, John	Anesthesia	INDIRECT. Processing cardiac interval timing to monitor contractile state under varying loads and drugs.	GM00862	NIH	72,871.00	S	0.0	0.0	0.935

SUMMARY OF COMPUTER RESOURCE USAGE

April 17, 1971 - April 16, 1972

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INVESTIGATOR	DEPARTMENT/ INSTITUTION	PROJECT TITLE	DIRECT GRANT OR CONTRACT SUPPORT Identification Number	Agency	Current Annual Amt.	BRR Category*	AMOUNT OF USAGE - TIME SHARING COMPUTER Terminal Access Hours	Pageminutes(K) @ $ .01 per pageminute	Block Storage(K) (Block=2k bytes) @ $ .10 per block
Category 2 (cont'd.)	Non-Realtime, Sponsored Research (CHARGEABLE)								
Reynolds, Walter	Genetics	VIKING75. Text editing and logic development for computer instrumented checkout of scientific instruments designed to fly on the VIKING 75 mission to Mars.	RCO-446200	Air Force	$ 49,824.00	S	16.4	3.544	0.419
Reynolds, Walter	Genetics	TEXTS. Text management support for engineering efforts in instrumentation: commercial technical data and information retrieval programs.	NGR004	NASA	240,000.00	S	49.0	58.781	5.269
Rindfleisch, Thomas	Genetics	DENDRAL. Mass spectra analysis and interpretation.	RR00612	NIH	295,125.00	S	8.7	3.543	0.010
Robertson, William	Pediatrics	UGAG. Urinary analysis of glycosamenoglycans; immunoglobin concentrations in sera; binding of ligands to macromolecules.	--	Hartford Fdn.	50,000.00	S	18.3	6.786	0.234
Rosenberg, Leon	Med. Microbiology	ALEXINE. Studies of serum complement in mice.	AI09341	NIH	49,202.00	S	72.8	24.225	0.447
Rosenberg, Saul	Radiology	MEDONCOL. Development of time-oriented patient record system for patients with malignant diseases.	CA08122	NIH	253,471.00	C	427.9	235.614	10.693
Rosenquist, Grace	Gastroenterology	GASTRIN. Calculation of serum gastrin concentrations of normals and patients with G.I. tract diseases.	AM06971	NIH	92,644.00	S	25.4	5.297	0.110
Russell, Alan	Biochemistry	AFFINITY. Enzyme assay calculation.	GM07581	NIH	299,344.00	S	42.8	9.909	0.390
Schubert, Earl	Otolaryngology	SONICS. Analysis of signal waveforms by Fourier, correlational and similar techniques.	--	Sonic Research Fdn	--	S	0.0	0.0	0.024
Shaw, Natalie	Orthopedics	CRASH. Calculation of vehicle dynamics, occupant kinematics, and loading for multidisciplinary investigation of automobile crashes.	HS-085-1	DOT	106,500.00	S	0.0	0.0	0.015
Simpson, Jack	Physics	SUSIE. Design work for a superconducting magnetic beam transport channel for use in pion cancer therapy.	GP27708	NSF	375,000.00	S	104.2	60.376	2.588
Sklar, Alan	Psychiatry	CATAPULT. Relationship of parental separations during the first 18 years of life and personality characteristics of children.	--	Univ Funds	--	S	0.0	0.0	0.002
Smith, James	Med. Microbiology	CANVIR. Development of automated system for classification of human chromosomes.	NCI-69-2053	NIH	179,810.00	S	236.9	326.890	11.480
Smith, Kendric	Radiobiology	CHBR. Data analysis of sedimentation patterns of DNA following X-irradiation.	CA10372	NIH	498,286.00	S	157.9	36.980	0.221
Solomon, George	Psychiatry	STRESS. Relating various forms of stress and environmental manipulation to immunity.	--	Scottish Rite	20,154.00	S	20.9	5.438	0.574

SUMMARY OF COMPUTER RESOURCE USAGE

April 17, 1971 - April 16, 1972

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INVESTIGATOR	DEPARTMENT/ INSTITUTION	PROJECT TITLE	DIRECT GRANT OR CONTRACT SUPPORT Identification Number	Agency	Current Annual Amt.	BRR Category*	AMOUNT OF USAGE - TIME SHARING COMPUTER Terminal Access Hours	Pageminutes(K) @ $ .01 per pageminute	Block Storage(K) (Block=2K bytes) @ $ .10 per block
Category 2 (cont'd.)	Non-Realtime, Sponsored Research (CHARGEABLE)								
Spevac, Abraham	Psychiatry	CONDIT. Analysis of data from behavioral and neurophysiological experiments on monkeys and cats.	MH08304	NIH	$253,794.00	S	10.0	5.071	0.305
Stark, George	Biochemistry	CHAOS. Enzyme experiment data analysis and processing of chromatograms generated by an amino acid analyzer.	GM11788	NIH	80,732.00	S	71.4	20.435	1.748
Stocker, Bruce	Med. Microbiology	STM. Genetics and physiology of salmonella typhimurium.	AI07168	NIH	90,515.00	S	46.3	14.413	9.071
Strickland, Robert	Gastroenterology	GASTRIC. Analysis of gastric secretory function tests.	AM05418	NIH	64,852.00	S	0.0	0.0	0.300
Stuedeman, Don	Genetics	ADMIN. Capital equipment inventory.	NGR004	NASA	240,000.00	S	0.0	0.0	1.992
Sussman, Howard	SUH - Clin Lab Pathology	CL050937. Statistical analysis programs for data generated by Clinical Laboratory Information System.	--	Hosp. Funds	--	C	145.3	35.321	1.138
Swartout, William	Comm & Prev Med	AIRPOLLU. Evaluation of the effects of air pollution on student health.	GY08322	NSF	10,758.00	S	0.0	0.0	0.010
Vosti, Kenneth	Infectious Disease	VOSTI. Cross-tabulation of variables associated with bacterial infections.	AI03638	NIH	40,924.00	S	7.3	2.433	2.364
Weissman, Irving	Pathology	THYMUS. Statistical analysis and data handling for pathology research.	AI09072	NIH	50,184.00	S	31.4	7.342	0.455
Whitson, Robert	Regional Medical Program	MPS EVAL. Evaluation of multiphasic screening project in San Joaquin County to discover its effect on disease treatment patterns.	--	CCRMP	63,900.00	S	102.2	43.516	4.600
Wolcott, Lesley	Psychiatry	MINPIN. Testing statistical correlations between drug and non-drug data, e.g., amphetamines, placebos, THC, etc.	MH19918	NIH	74,666.00	S	4.6	0.965	0.119
					SUB-TOTAL		11590.9	6320.625	446.608
Category 3	Non-Stanford Medical (CHARGEABLE)							@ $ .02 per pageminute	@ $ .10 per block
Belt, Donald	Otolaryngology	SEC. Process and evaluate hearing and vision screening data.	--	Personal Funds	--	S	0.3	0.079	0.030
Daughters, George	Palo Alto Medical Research Fdn.	CINES. Myocardial dynamics.	--	PAMR	--	S	86.1	22.546	0.647
Daughters, George	Palo Alto Medical Research Fdn.	LABCHECK. Routine terminal use for PAMR Clinical Laboratory.	--	PAMR	--	S	35.9	7.527	0.145
Daughters, George	Palo Alto Medical Research Fdn.	PLAYTIME. Instruction in computer use for PAMR staff.	--	PAMR	--	T	6.9	1.497	0.386

SUMMARY OF COMPUTER RESOURCE USAGE

April 17, 1971 - April 16, 1972

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Category 3 (cont'd.)	Non-Stanford Medical (CHARGEABLE)							@ $ .02 per pageminute	@ $ .10 per block
Efron, Brad	Statistics	EFRON. Biostatistical analysis of drug data.	--	Personal Funds	--	S	11.7	3.747	0.317
Kountz, Samuel	San Francisco Medical Center	KIDNEY. Selection of recipients for renal homotransplantation; measurement and calculation of hemodynamic changes in transplant patients for detection of incipient rejection.	--	Univ. of California	--	S	314.3	230.367	2.915
Tickner, Ernest	Palo Alto Medical Research Fdn.	VISCOUS. Viscous behavior of blood.	--	PAMR	--	S	46.3	20.892	0.314
					SUB-TOTAL		501.5	286.655	4.754
Category 4	Medical Students (FREE)							@ $ .01 per pageminute	@ $ .10 per block
Battista, John	Student	STRESS. Analysis of questionnaire administered to medical students regarding meaningfulness of various factors in their lives.				T	112.1	27.720	5.099
Brast, Neil	Student	RODENTS. Statistical programs for student's research.				T	0.3	0.054	1.228
Britt, Richard	Student	STARR. Auditory pathway responses to meaningful acoustic stimuli.				T	0.0	0.002	0.077
Brody, William	Student	FLYHIGH. History taking and formation of differential diagnoses.				T	0.0	0.0	1.309
Brown, Byron	Biostatistics	CLASS. Classwork for course in biostatistics.				T	10.7	2.464	2.088
Brown, B. Norman	Student	PROTEIN. Correlation of serum level of therapeutic agents with age, body weight, surface area, etc; pharmacotherapy study of 900 hospitalized pediatric patients.				T	0.1	0.024	4.525
Brunda, Michael	Student	MEDMICRO. Evaluation of data from gamma counter on per cent cytotoxicity in cell suspensions exposed to a variety of developed antisera against thymus and brain determinants.				T	0.0	0.016	0.009
Buchanan, Bruce	Computer Science	STAT. Statistical demonstration programs for a course in biostatistics.				T	51.2	14.916	6.204
Buchanan, Bruce	Genetics	GEN217. Computer instruction for medical students in Genetics Department.				T	257.9	113.604	4.908
Bull, Kenneth	Student	K BULL. Effects of injections of epinephrine v. nor-epinephrine on agonistic (agressive, withdrawal, fear) and autistic behaviors in Rhesus monkeys.				T	14.1	5.285	0.187

SUMMARY OF COMPUTER RESOURCE USAGE

April 17, 1971 - April 16, 1972

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Category 4 (cont'd.)	Medical Students (FREE)								
Calvert, James	Student	TEXT. Solving the economic problem of medical research funds allocation; one criterion: change in mortality rate.				T	18.6	3.992	1.645
Cavalli, Luca	Genetics	HUMGEN. Classwork for course in human genetics.				T	124.1	36.797	0.519
Chester, Thomas	Student	PLAQUE. Anti-tumor immune responsive effects of interferon and interferon inducers.				T	79.1	29.607	1.775
Chiampi, Nona	Student	MEMBTSTA. Calculation of enzyme activities and carbohydrate content of cell fractions.				T	2.9	0.768	0.096
Chu, Fred	Student	OMNI. Automatic recognition of cardiac arrhythmias on monitored patients.				T	1.9	0.507	2.155
Corby, James	Student	HURRY. Relationship between attention and enhancement of average evoked response (AER) magnitude.				T	20.4	6.130	2.229
Dimsdale, Joel	Student	GETPEACE. Characterization of goals in psychiatric wards and ward pressures on patients and staff to conform to the goals.				T	83.6	25.430	3.749
Dubowy, Ronald	Student	TURTLE. Enzyme changes in the skeletal muscles of chronically exercized rats.				T	7.1	3.142	0.152
Enzmann, Dieter	Student	SWALLOW. Determination of secondary peristalsis of the esophagus.				T	137.6	54.299	7.958
Feldman, Gary	Student	ASTHMA. Monitoring of airway resistance values during sessions with asthmatic patients and normal subjects.				T	0.0	0.0	0.120
Filman, David	Student	NEURON. Neural network model: rotation of visual pattern in accordance with vestibular input.	[illegible]			T	1.4	0.300	0.039
Funk, Glenn	Student	RHINO. Study of rhinoviruses.				T	0.7	0.161	0.101
Gamel, John	Student	DOGLAB. Indicator dilution techniques for measuring pulmonary blood flow and lung transfer function.				T	0.1	0.019	4.728
Gelfand, Michael	Student	CARCAT. On-line analysis of cardiac catheterization data.				T	0.0	0.0	0.206
Gleason, Curtis	Student	CORTMEAS. Study of transmembrane currents as a function of depth of brain cortex.				T	0.0	0.0	0.120
Gordon, Louis	Student	CONFID. Monte Carlo study of the characteristics of the Hartigan subsampling method for generating confidence intervals.				T	7.0	4.044	0.202

SUMMARY OF COMPUTER RESOURCE USAGE

April 17, 1971 - April 16, 1972

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Category 4 (cont'd)	Medical Students (FREE)								
Hahn, Peter	Student	OXYTOX. Interpretation,quantification, and systematic retrieval of information from gel electrophoreses.				T	6.8	4.073	0.418
Harris, Robert	Student	PNP. Correlation of subjects' emotions with their appraisals of certain aspects of their environments.				T	0.0	0.0	2.552
Helikson, Mary	Student	LBF. Measure of liver blood flow in dogs by radioisotope disappearance and electromagnetic flow meter determination.				T	36.8	22.880	0.946
Jacobs, Beverly	Student	COMPUTE. Thesis research project on mechanism of insulin action.				T	44.6	13.792	0.668
Jan, Wesley	Student	NOMAN. Information processing, storage, retrieval and display for students' research on enumerating a minor cell population by fluorescent techniques.				T	142.4	51.848	2.405
Lenssen, Barbara	Student	INFANTS. Analysis of data for doctoral dissertation on infants' fear of strangers.				T	15.8	3.632	0.030
Levine, Rodney	Student	CPS. Clarification of mechanisms of pyrimidine synthesis in mammals and the relationship of that synthesis to the control of cellular proliferation.				T	48.1	26.509	3.926
Lipp, Martin	Student	MEDSPOT. Survey of marijuana use among medical personnel.				T	19.9	6.382	17.968
Masover, Gerald	Student	MYCOPLAS. Amino acid analysis of media used for growth of mycoplasma and tissue culture cells.				T	12.7	3.450	0.023
Miller, Craig	Student	CAB. Development of risk/benefit guidelines for saphenous vein - coronary artery bypass surgery.				T	26.1	17.646	0.366
Miller, Stephen	Student	LEARN. Analysis of data from an ANGER scintillation camera in connection with kidney blood flow studies; computer diagnosis of liver and cardiac disease.				T	53.9	29.779	7.467
Mischak, Ronald	Student	HISTOCOM. Evaluation of data from gamma counter on per cent cytotoxicity in cell suspensions exposed to a variety of developed antisera against thymus and brain determinants.				T	0.1	0.023	0.016
Mobley, William	Student	NBIOCMED. Statistical analysis for thesis project on proteins; storage of research notes and data, edited class notes and references.				T	0.2	0.048	0.004

SUMMARY OF COMPUTER RESOURCE USAGE

April 17, 1971 - April 16, 1972

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Category 4 (cont'd.	Medical Students (FREE)								
Neff, Nicola	Student	POLYRIBO. Extraction of polyribosomes and ribosomes from human fibroblast cells in culture to determine relative proportions and quantity throughout cell life culture.				T	19.5	10.027	0.358
Nestor, Larry	Student	DIFFDX. Establishment of computer program to aid in differential diagnosis.				T	66.3	33.686	1.545
Nola, Gaeton	Student	DIGMI. Effects of several drugs on hemodynamic parameters in dogs.				T	23.4	6.048	1.032
Nuwer, Marc	Student	NEURON. Modeling of interactions of groups of neurons.				T	0.1	0.016	0.027
Odell, Robert	Student	CIS. Inactive				T	0.0	0.0	0.024
Peters, John	Student	BIOSTAT. Evaluation of residuals and outliers in parallel line assays and their effect on statistical analysis of clinical data.				T	1.2	0.245	0.006
Peterson, Daniel	Student	MODELIN. Formulation of comprehensive model for insulin metabolism in the human body.				T	71.2	44.729	1.425
Pope, Stephen	Student	AY21011. Cardiovascular function parameters of various pharmacologic agents.				T	0.3	0.053	0.332
Propper, Richard	Student	TEST1. Study of inter-relationship of annogenesis and glucomedgenesis in the perfused rat kidney.				T	0.0	0.0	0.040
Raybin, Daniel	Student	ASSAYS. Calculation of enzyme assays and enzyme kinetics.				T	82.6	24.074	0.599
Rosenfeld, Ron	Student	CCUPSYCA. Study of psychophysiological adaptation of male patients to the Coronary Care Unit.				T	0.0	0.0	0.024
Rosenthal, William	Student	RESEARCH. Auditory processing in language deviant children; longitudinal study and follow-up of language deviant children.				T	20.2	5.516	0.744
Sachs, David	Student	POPCIT. Statistical analysis of questionnaires completed by newspaper reporters and editors on their attitudes and orientations toward environmental health issues.				T	197.4	80.769	13.766
Sack, Robert	Student	MASOCH. Item analysis of questionnaire to determine which questions best discriminate between normals and psychiatric patients; also cluster analysis for internally correlative items.				T	5.4	1.147	0.019
Saffir, Arthur	Histochemistry	ORALBIOL. Computer instruction in biostatistics for dental students.				T	40.6	14.492	0.454

SUMMARY OF COMPUTER RESOURCE USAGE

April 17, 1971 - April 16, 1972

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Category 4 (cont'd.)	Medical Students (FREE)							@ $ .01 per pageminute	@ $ .10 per block
Scandella, Carl	Student	GREASBAL. Study of modifications in the chemical structure of the cytoplasmic membrane of bacteria induced by viral infection.				T	0.2	0.034	0.735
Schwartz, Barry	Student	CELLCOUN. Analysis of Coulter Counter data for study of aging process at cellular level.				T	3.2	0.786	0.005
Sethi, Sarvan	Student	ISOTOPE. Replication of rhinoviruses in cell cultures.				T	0.4	0.086	0.634
Siever, Larry	Student	GRADIENT. Study of gradients of biogenic amines in the spinal cord cerebrospinal fluid.				T	6.3	4.182	0.012
Sinclair, Allen	Student	HEARTCEL. Measurement of intervals between beats of individual heart cells and administration of drugs to cells to change environmental conditions.				T	3.8	0.801	0.410
Spinelli, Nico	Psychiatry	COMPBIOL. Class account for "Computers in Biology and Medicine."				T	22.7	7.431	0.027
Sproul, Myrna	Student	FETAL. Data analysis for thesis project on relationship of maternal corticosteroids to the development of the fetal hypothalmic-pituitary-adrenal axis.				T	0.2	0.063	0.004
Swanson, George	Student	THESIS. Interpretation of therapeutic drug action on respiratory control.				C	578.6	394.999	17.322
Thomas, Hank	Student	AC DISP. Real time game putting players under pressure to make operational and economic decisions under a time constraint.				T	1.3	0.280	0.192
Wiskocil, Robert	Student	ULTRA. Study of enzyme mechanism of tryptophan synthesis using equilibrium dialysis technique.				T	0.0	0.0	0.012
Unknown Users	Mostly Students	SCRATCH. Minor use of the system without data storage.				T	890.2	298.525	0.285
					SUB-TOTAL		3373.4	1437.332	128.300
Category 5 Realtime	Core Research (FREE)							@ $ .005 per pageminute	@ $ .10 per block
Reynolds, Walter	Genetics	DREAMS. DENDRAL: Mass spectra analysis and interpretation.				Cor	11.8	3.398	11.505
Ross, Robert	Chemistry	CHEM. DENDRAL: Mass spectra analysis and interpretation.				Cor	5.6	1.646	8.885
Sera, Hiram	SUH - Pharmacy	ALERT. Drug Interaction project, hospital pharmacy service.				Cor	0.0	0.0	0.002

SUMMARY OF COMPUTER RESOURCE USAGE

April 17, 1971 - April 16, 1972

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Category 5 (cont'd.)	Realtime, Core	Research (FREE)						@ $ .005 per pageminute	@ $ .10 per block
Stillman, Robert	Chemistry	DREAMS. DENDRAL: Mass spectra analysis and interpretation.				Cor	39.3	18.333	6.292
					SUB-TOTAL		56.7	23.377	26.684
Category 6	Non-Realtime, Core Research	(FREE)						@ $ .01 per pageminute	@ $ .10 per block
Cohen, Stan	Clinical Pharmacology	DRUGALRT. Computerized system to warn of interactions of drugs administered to patients.				Cor	972.5	786.461	68.211
Lederberg, Joshua	Genetics	PILOT1. Demonstration programs.				Cor	313.2	145.141	24.613
Lederberg, Joshua	Genetics	PILOT2. System testing and monitoring.				Cor	139.9	64.494	9.031
Reynolds, Walter	Genetics	DENDRAL: Mass spectra analysis and interpretation.				Cor	80.9	103.498	1.496
Ross, Robert	Chemistry	DENDRAL: Mass spectra analysis and interpretation.				Cor	146.2	181.503	2.783
Stefik, Mark	Genetics	DENDRAL: Mass spectra analysis and interpretation.				Cor	130.1	69.335	1.919
Stillman, Robert	Chemistry	DENDRAL: Mass spectra analysis and interpretation.				Cor	106.8	95.493	0.998
					SUB-TOTAL		1889.6	1445.925	109.051
Category 7	Staff (FREE)							@ $ .01 per pageminute	@ $ .10 per block
Bassett, Robert	ACME	ACMECONS. Applications program development; user consultation.				Cor	600.3	198.308	6.391
Baxter, Erica	ACME	NOTES. Maintenance of ACME Note index and list of user publications.				Cor	45.0	17.416	6.169
Baxter, Erica	ACME	TRAINING. ACME user accounting records.				Cor	32.0	9.627	1.823
Becker, Sheldon	Computation Center	ACME. System development and testing.				Cor	0.8	0.470	0.018
Beebe, Robert	Computation Center	OS. System development and testing.				Cor	0.7	0.300	0.018
Berman, Joseph	ACME	RACME. System development and testing.				Cor	133.0	63.488	11.716
Berns, Robert	ACME	LISP. System development and testing.				Cor	30.5	45.675	3.717
Berns, Robert	ACME	DENDRAL. System development and testing.				Cor	75.4	136.881	14.392

SUMMARY OF COMPUTER RESOURCE USAGE

April 17, 1971 - April 16, 1972

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Category 7 (cont'd.)	Staff (FREE)								
Briggs, Russell	ACME	RBPDP11. Disc monitor for PDP-11.				Cor	178.4	84.837	9.353
Briggs, Russell	ACME	ACME. System development and testing.				Cor	13.1	3.645	4.565
Brown, Byron	Biostatistics	INTRO. Special course for students to learn to use ACME.				T	59.9	14.364	0.850
Carr, Richard	Computation Center	ACME. System development and testing.				Cor	1.4	0.750	0.022
Class, Charles	ACME	ACME. Operations management; system testing and demonstration.				Cor	5523.5	3061.554	27.943
Copeland, Art	Computation Center	OS. System development and testing.				Cor	0.0	0.0	0.040
Cower, Rich	ACME	FLOWERED. Daily operations.				Cor	297.5	110.979	2.816
Crouse, Linda	ACME	CATH LAB. Development of real-time medical applications.				Cor	33.7	8.980	35.572
Feigenbaum, Edward	Computation Center	TO29TEST. System demonstrations.				Cor	0.0	0.0	0.024
Feigenbaum, Edward	Computation Center	DEMOS. System demonstrations.				Cor	0.0	0.0	0.132
Freret, Payne	ACME	LOMA. Development of graphics software.				Cor	193.5	71.457	1.862
Frey, Regina	ACME	ACME. File system testing; consulting programs.				Cor	92.1	42.976	14.944
George, Denise	Computation Center	OS. System development and testing.				Cor	0.0	0.0	0.024
Gold, Don	Computation Center	ACME. System development and testing.				Cor	0.4	0.079	0.227
Granieri, Chuck	ACME	ACME. System development and testing.				Cor	86.4	30,889	1.506
Hale, Robert	ACME	TPNG. System development and testing.				Cor	47.2	19.885	1.109
Hu, Jean	ACME	ACME. System development and testing.				Cor	370.0	367.851	9.347
Hundley, Lee	ACME	ACME. System development and testing; emphasis on real-time data acquisition.				Cor	318.1	122.221	10.817
Jamtgaard, Ron	ACME	GOAL. Director's office projects.				Cor	65.0	25.275	4.806
Jamtgaard, Ron	ACME	MYJOB. Task management.				Cor	0.0	0.0	0.360
Lederberg, Joshua	Genetics	MEMOPAD. Text editing.				Cor	0.0	0.0	0.861
Lederberg, Joshua	Genetics	MISC. Program development.				Cor	8.2	3.273	6.944
Lederberg, Joshua	Genetics	TESTS. Systems tests.				Cor	45.7	14.086	2.689
Leong, Leon	ACME	WORK. Development of applications program.				Cor	36.1	24.787	0.029
Lew, Ying	ACME	SUMMER. System development and testing.				Cor	104.8	35.532	2.549
Martin, Charles	Computation Center	ACME. System development and testing				Cor	0.3	0.059	0.024
Matheson, Russ	ACME	PI. System development and testing.				Cor	231.0	181.282	2.250

SUMMARY OF COMPUTER RESOURCE USAGE

April 17, 1971 - April 16, 1972

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Category 7 (cont'd.)	Staff (FREE)							@ $ .01 per pageminute	@ $ .10 per block
Matous, James	ACME	GET. Daily operations.				Cor	8.2	3.618	0.603
Miller, Stu	ACME	ACME. System development and testing.				Cor	199.0	82.841	2.227
Montgomery, Richard	Computation Center	KP. Text editing.				Cor	0.0	0.0	0.024
Moore, James	Computation Center	OS. System development and testing.				Cor	0.0	0.0	0.020
Nozaki, Tom	ACME	ENGINEER. Engineering applications.				Cor	15.9	5.809	1.651
Osborne, De Wayne	ACME	ENGINEER. Engineering applications.				Cor	18.6	4.715	0.473
Pearson, Joan	Computation Center	OS. System development and testing.				Cor	0.0	0.0	0.020
Reynolds, Walter	Genetics	HIQ. System development and testing.				Cor	62.1	34.804	3.213
Richardson, Ruth	Computation Center	OS. System development and testing.				Cor	0.0	0.0	0.020
Rieman, James	ACME	VAT. Daily operations.				Cor	50.6	18.191	0.267
Sanders, Bill	ACME	ASDBG. Hardware and software development.				Cor	0.7	0.507	2.671
Sanders, Gary	ACME	CONSULT. User consultation.				Cor	20.2	7.235	1.315
Sandoval, Charles	ACME	ACME. Daily operations.				Cor	0.8	0.213	0.696
Scharf, Guy	Computation Center	OS. System development and testing.				Cor	0.0	0.0	0.020
Stainton, Robert	ACME	SCC. System development and testing.				Cor	23.1	5.229	0.108
Stubbs, Bert	Computation Center	ENGINEER. Engineering applications.				Cor	0.0	0.0	0.024
Sutter, Jan	ACME	ACME. Daily operations.				Cor	95.9	21.643	8.509
Tice, Bernie	Computation Center	ACME. System development and testing.				Cor	0.0	0.0	0.020
Tribolet, Chuck	ACME	CAI. Development of computer-aided instruction for teaching PL/ACME.				Cor	110.0	43.776	0.793
Vallee, Jacques	Computation Center	DIRAC2. Automation of Stanford Blood Bank.				Cor	0.0	0.0	0.008
Vantassel, James	ACME	TEST. Daily operations.				Cor	12.7	3.080	0.120
Weyl, Steve	ACME	SWEYL. Applications program development.				Cor	40.3	24.094	0.046
Whitner, Jane	ACME	STATISTI. Statistical program development.				Cor	493.4	217.913	6.854
Whitner, Jane	ACME	STATTEST. Statistical program development.				Cor	0.0	0.0	0.732
Wholey, Anna	ACME	ACME. Development of applications programs.				Cor	0.0	0.0	0.012
Wiederhold, Gio	ACME	TEST. System testing.				Cor	175.0	83.978	9.031
Wiederhold, Gio	ACME	USAGE. Usage statistics, accounting and yearly reports.				Cor	0.4	0.093	8.724

SUMMARY OF COMPUTER RESOURCE USAGE

April 17, 1971 - April 16, 1972

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Category 7 (cont'd.) Staff (FREE)									
Wiederhold, Gio	ACME	CSMP. Continuous system modeling program development.				Cor	0.4	0.081	4.163
Wiederhold, Gio	ACME	DEMO. Demonstration for ACME visitors.				Cor	65.6	17.539	4.164
Wiederhold, Voy	ACME	MANUAL. Maintenance of PL/ACME Manual.				Cor	97.9	43.925	20.369
Wilson, Don	ACME	ACME. Development of real-time medical applications.				Cor	0.0	0.0	1.964
ACME Staff	ACME	JQPUBLIC. Development and storage of PUBLIC files.				Cor	51.7	15.821	9.107
ACME Staff	ACME	I GRAPH OPS. Graphics development.				Cor	0.5	0.182	0.845
ACME Systems Staff	ACME	PROGRAMS. Collection of systems programs.				Cor	23.3	9.815	0.516
IBM Customer Engineers	IBM	I CE TERMDIAG. Terminal testing and diagnosis.				Cor	112.0	30.590	0.830
PL/ACME Classes	ACME	PLACME. Practice programming for PL/ ACME classes.				T	315.7	114.172	1.764
					SUB-TOTAL		10618.0	5486.790	277.832
Category 8 Hospital Data Processing (CHARGEABLE)								@ $ .0125 per pageminute	@ $ .10 per block
Barber, Vic	SUH - Data Processing	SUHDP. Accounting.		Hosp. Funds		S	1.8	0.523	0.036
Boyle, James	SUH - Clinics	CBO. Accounting.		Clinic Budget		S	344.9	294.220	18.556
					SUB-TOTAL		346.7	294.743	18.592
Category 10 Realtime, Pilot and Pending Proposal (FREE)								@ $ .005 per pageminute	@ $ .10 per block
Borison, Scott	Cardiovascular Surgery	FLOW. Simulation of physiological properties.				S	0.2	0.104	0.048
Bunnenberg, Edward	Chemistry	CHEM. Development of a magnetic circular dichroism biotechnology resource.				S	178.7	205.367	3.421
Kadis, Leslie	Anesthesia	VISAEP. Visual average evoked potential to graded light intensity as a correlate of pain threshhold.				C	67.5	56.045	0.280
Roth, Walton	Psychiatry	AER. Research into computer processing of EEG data.				S	29.4	18.831	0.662

SUMMARY OF COMPUTER RESOURCE USAGE

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Category 10 (cont'd.)	Realtime, Pilot and Pending Proposal (FREE)							@ $ .005 per pageminute	@ $ .10 per block
Sussman, Howard	SUH - Clin. Lab. Pathology	LABENG. Connection of a large analysis instrument in the Clinical Laboratory to the 1800 for data collection.				S	60.9	15.404	0.159
					SUB-TOTAL		336.7	295.751	4.570
Category 11	Non-Realtime, Pilot and Pending Proposal (FREE)							@ $ .01 per pageminute	@ $ .10 per block
Belt, Donald	Otolaryngology	HEAR. Collection and processing of hearing loss data.				S	2.4	0.539	0.036
Bunnenberg, Edward	Chemistry	CHEM. Development of a magnetic circular dichroism biotechnology resource.				S	52.3	27.754	4.185
Butler, Edmund	Urology	UROCTATS. Urology operative statistics information and retrieval program.				S	9.6	7.254	0.833
Cavalli, Luca	Genetics	PAVIA. Population genetics: evolutionary rate, patterns of inheritance in behavioral traits, analysis of record linkage and pedigree information.				S	126.4	64.750	2.467
Costell, Ronald	Psychiatry	AHSO. Analysis and statistical testing of factors of significance in the sexual histories of sex offenders.				S	14.0	3.688	0.383
Eddy, David	Engineering	NIFTY. Use of a Markov model of coronary artery disease for optimum treatment decision.				S	12.0	4.854	0.046
Goldstein, Avram	Pharmacology	OFFSTUFF. Study of methadone maintenance program for heroin addicts.				S	38.4	53.662	1.137
Leiderman, P. Herbert	Psychiatry	KENYA. Analysis of data collected in Kenya, relating the effect of social structure of primary family on infants' social attachments in the first year of life.				S	57.7	20.818	1.291
					SUB-TOTAL		312.8	183.319	10.378
Category 12	Realtime, Extended Non-Funded (FREE)							@ $ .005 per pageminute	@ $ .10 per block
Cady, Paxton	Psychiatry	THYROID. Study of the relationship between stress and a partial genetic defect in thyroid function.				S	0.0	0.0	12.212
Constantinou, Christos	Urology	UROL. Investigation of upper urinary tract physiology.				C	394.1	237.597	2.537
Govan, Duncan	Urology	PARAQUAD. Urologic evaluation management and clinical follow-up of patients with spinal cord injury or disease.				S	0.0	0.0	0.281
					SUB-TOTAL		394.1	237.597	15.030

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Category 13 Non-Realtime, Extended Non-Funded (FREE)								@ $ .001 per pageminute	@ $ .10 per block
Cann, Howard	Pediatrics	DTS/GUAT. Population genetics studies of Mayan Indians of Guatemala.				S	2.8	0.701	1.603
					SUB-TOTAL		2.8	0.701	1.603
Category 16 Combination of Core Research and Application (CHARGEABLE)								@ $ .0025 per pageminute	@ $ .10 per block
Sera, Hiram	SUH - Pharmacy	ALERT. Drug Interaction Project, hospital pharmacy service.	--	Hosp. Funds	--	S	1876.1	3077.508	30.317
					SUB-TOTAL		1876.1	3077.508	30.317
Category 9 Non-Health-Related Users (CHARGEABLE)								@ $ .025 per pageminute	@ $ .10 per block
					SUB-TOTAL		1374.8	564.419	26.803
					GRAND TOTAL		40391.5	25317.306	1349.403
					Number of Projects				
		Core Research and Development			80		12188.7	6827.556	410.953
		Collaborative			20		7873.9	5578.912	253.218
		Service			165		15395.0	10994.833	541.002
		Training			72		3559.1	1351.586	117.427
		SUB-TOTAL			337		39016.7	24752.887	1322.600
		Non Health-Related Research			32		1374.8	564.419	26.803
		GRAND TOTAL			369		40391.5	25317.306	1349.403

Time scheduled for users	6595 hrs.
Time not available to users due to failures	112.3 hrs.
Percentage of scheduled time not available to users	1.7 %

IX. PUBLICATIONS

A. Published in Regularly Scheduled Periodicals During Fiscal 1972

Ammerman, A., and L.L. Cavalli-Sforza, "Measuring the Rate of Spread of Early Farming in Europe," MAN, Vol. 6, pp. 674-688, December 1971.

Chester, T., P. DeClercq, and T. Merigan, "PolyrI, PolyrC and Antibody, Interferon, and Phagcytosis," INFECTION AND IMMUNITY, April 1971.

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Glick, D., K. Marich, J. Orenberg, P. Carr, and D. Miller, "Effect of Atmosphere on Spectral Emission from Plasmas Generated by the Laser Microprobe," ANALYTICAL CHEMISTRY, Vol. 43, pp. 1452-1456, September 1971.

Ingels, N.B., Jr., G.T. Daughters, II, S.R. Davies, and I.B. MacDonald, "Stereo Photogrammetric Studies on the Dynamic Geometry of the Canine Left Ventricular Epicardium," J. BIOMECHANICS, Vol. 4, pp. 541-550, 1971.

Kaplan, B.E., J.C. Corby, and P.H. Leiderman, "Attention and Verbalization: Differential Responsivity of Cardiovascular and Electrodermal Systems," JOURNAL OF PSYCHOSOMATIC RESEARCH, Vol. 15, pp. 323-328, 1971.

Levine, R. and N. Kretchmer, "Conversion of Carbamyl Phosphate to Hydroxyurea: An Assay for Carbamyl Phosphate Synthetase," ANALYTICAL BIOCHEMISTRY, Vol. 42, No. 2, pp. 324-337, August 1971.

Levine, R., N. Hoogenroad, and N. Kretchmer, "Copurification of Carbamoyl Phosphate Synthetase and Aspartate Transcarbamoylase from Mouse Spleen," BIOCHEMICAL AND BIOPHYSICAL RESEARCH COMMUNICATIONS, Vol. 44, pp. 981-988, 1971.

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Morris, S., H. Ralston, and . Shooter, "Studies on the Turnover of Mouse Brain Synaptosomal Proteins," J. NEUROCHEM., Vol. 18, pp. 2279-2290, 1971.

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Pauling, L., A.R. Robinson, R. Teranishi, and P. Cary, "Quantitative Analysis of Urine Vapor and Breath by Gas - Liquid Partition Chromatography," PROC. NAT. ACAD. SCI. USA, Vol. 68, No. 10, pp. 2374-2376, October 1971.

Silbergeld, S., N. Brast, and E. Noble, "The Menstrual Cycle: A Double-Blind Study of Symptoms, Mood, and Behavior, and Biochemical Variables Using Enovid and Placebo," PSYCHOSOMATIC MEDICINE, Vol. 33, p. 411, 1971.

Swanson, G., T. Carpenter, D. Snider, and J. Bellville, "An On-Line Hybrid Computing System for Dynamic Respiratory Response Studies", COMPUTERS AND BIOMEDICAL RESEARCH, Vol. 4, pp. 205-215, April 1971.

Teranishi, R., T.R. Mon, A.B. Robinson, P. Cary, and L. Pauling, "Gas Chromatography of Volatiles from Breath and Urine," ANALYTICAL CHEMISTRY, Vol. 44, p. 18, January, 1972.

Thoman, E., C. Barnett, and P. Leiderman, "Feeding Behaviors of Newborn Infants as a Function of Parity of the Mother," CHILD DEVELOPMENT, Vol. 42, pp. 1471-1483, 1971.

Thoman, E., J. Olson, and P. Leiderman, "Neonate-Mother Interaction During Breast-Feeding," DEVELOPMENTAL PSYCHOLOGY, Vol. 6, No. 1, pp. 110-118, 1972.

Thoman, E. and A. Korner, "Effects of Vestibular Stimulation on Behavior and Development of Infant Rats," DEVELOPMENTAL PSYCHOLOGY, Vol. 5, No. 1, pp. 92-98, 1971.

Watson, W., H.M. Cann, E.M. Farber, and M.L. Nall, "The Genetics of Psoriasis," ARCH. DERM., Vol. 105, pp. 197-207, February 1972.

B.
Other Publications

Ammerman, A., and L.L. Cavalli-Sforza, "A Population Model for the Diffusion of Early Farming in Europe," Proceedings of the Research Seminar in Archaeology and Related Subjects, Sheffield, December 1971.

Barth, G., R.E. Linder, E. Bunnenberg, and C. Djerassi, "The Magnetic Circular Dichroism of Porphyrin Dications," presented at the April 3, 1972 Porphyric Conference sponsored by the New York Academy of Sciences, to be published in the ANN. N.Y. ACAD. SCI. (spring 1972).

Bernfield, M., "Chromatographic Properties of Pyrrolidone Carboxylate-tRNA," submitted to J. BIOLOGICAL CHEM. (spring 1972).

Bernfield, M., "Characterization of Pyrrolidone Carboxylate-RNA from Rat Liver," in preparation (spring 1972).

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Buchanan, B.G., E.A. Feigenbaum, and J. Lederberg, "A Heuristic Programming Study of Theory Formation in Science," Stanford Artificial Intelligence Project, Memo AIM-145, Computer Science Department Report CS 221, June 1971.

Buchanan, B.G., and J. Lederberg, "The Heuristic DENDRAL Program for Explaining Empirical Data," presented at the 1971 Congress of the International Federation of Information Processing Society (August 1971) and published by North Holland Publishing Co.

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Calvert, J.L. and J.H. Frenster, "Economics of Investment in Biomedical Research and Current Patient Care," CLINICAL RESEARCH, Vol. 19, p. 499, 1971 (abstract).

Cavalli-Sforza, L.L., "Pygmies, an Example of Hunters-Gatherers, and Genetic Consequences for Man of Domestication of Plants and Animals," IV INT. CONGR. HUMAN GENETICS, PROCEEDINGS, in press (spring 1972).

Cavalli-Sforza, L.L., and K. Kidd, "Considerations on Genetic Models of Schizophrenia," NEUROSCIENCES RESEARCH PROGRAM BULLETIN, in press (spring 1972).

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Constantinou, C., J. Sands, and D. Govan, "Computer Monitoring and Control Instrumentation in Urology Research," PROCEEDINGS OF THE 6TH ANNUAL BIOENGINEERING SYMPOSIUM, Fort Collins, Colo., May 1971.

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DeGrazia, J.A., and M.R. MacLaury, "Radiorespirometry Studies of the Effects of L-dopa and MK486 Therapy -- A Model Application of Carbon Isotopes to the in vivo Evaluation of Intermediary Metabolism During Clinical Drug Trials," accepted for publication by the AEC (spring 1972).

Dong, E., and G.C.M. Wiederhold, "The Use of a General-Purpose Time-Shared Computer in Physiology Research," to be published in the PROCEEDINGS OF THE NATIONAL CONFERENCE ON RESEARCH ANIMALS IN MEDICINE (spring 1972).

Farber, E.M., "Genetics of Psoriasis: Twin Study," in PSORIASIS: PROCEEDINGS OF THE INTERNATIONAL SYMPOSIUM, STANFORD UNIVERSITY, 1971, E.M. Farber and A.J. Cox (eds.), Stanford Press, 1971.

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Gold, J. A., G.S. Harrell, B.R. Bradley, and F.F. Zboralske, "Sequential Esophageal Blood Flow Determination," submitted to GASTROENTEROLOGY (spring 1972).

Gordon, L., "Completely Separating Groups in Subsampling," submitted to ANNALS OF MATH STATIST., (spring 1972).

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Hillman, R., "The Teaching of Psychotherapy Problems by Computer," ARCHIVES OF GENERAL PSYCHIATRY, in press.

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Kidd, K.K., and L.L. Cavalli-Sforza, "Number of Characters Examined and Error in Reconstruction of Evolutionary Trees," in MATHEMATICS IN THE ARCHAEOLOGICAL AND HISTORICAL SCIENCES, F.R. Hodson, D.G. Kendall, and P. Tautu (eds.), Edinburgh University Press, pp. 335-346, 1971.

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APPENDIX A

Summary of Campus/ACME Merger Study

ACME Note

ACM-1
Ron Jamtgaard
November 30, 1971

Summary of Campus/ACME Merger Study

The study of this potential merger has been limited to five specific areas:

- The capacity of the 360/67 to absorb the ACME load;
- An overview of services and cost considerations;
- A brief statement of the planned changes to the Campus Facility;
- A list of relative advantages and disadvantages of such a merger; and
- Comments on cost comparisons.

There follows a summary of considerations in these five areas.

360/67 Capacity:

In July a test was conducted to determine whether the 360/67 timesharing monitor called ORVYL could handle its current load plus ACME's current load plus the anticipated load associated with the new information retrieval system called SPIRES. The test indicated that the 360/67 had adequate cycles and performance capability to handle the anticipated SPIRES load plus a substantial ACME load based on current ACME usage levels. The 360/67 has considerable unused capacity today. The test of ORVYL capacity demonstrated that a considerably heavier load could be handled with acceptable degradation and response times to the user. The test did tax the capability of the system with respect to its paging system on the drums; but this was fully expected. The ACME portion of the test appeared to consume approximately 29 per cent of the 360/67 cycles. The simulation of the ACME load consisted of a series of FORTRAN routines which would require cycles corresponding to approximately 15 users in execution on the current ACME hardware (360/50 with 2 megabytes of 8 microsecond bulk core).

Overview of Service and Cost Considerations:

The Campus Facility provides the following services: production batch service, quick partition batch service, timesharing in at least three languages, text editing, (one of the best found anywhere), plotting, and remote job entry. Many languages are supported in the production batch partition. Rates for use of the system have been designed to remove administrative fiat with respect to scheduling of resource utilization. Thus, priority can be obtained by any user who is willing to pay a fee. No realtime support services are offered at the present time, although there is limited small machine support through the PDP-9.

Card readers are handled by both computer operators and users. Fast printing service is available and normally the turn around time is extremely good (a few minutes). Terminal services are normally offered between 8 a.m. and 1:00 a.m. except for brief periods of system staff time from 5 to 8 p.m. three days per week, plus some system time on weekends.

Comments On Planned Changes:

The Campus Facility is likely to acquire some new hardware by January 1973. The new hardware could either replace existing systems or could supplement them. For example, a fast batch engine could be acquired to support the current 360/67 services. It is essential that any potential hardware changes in the Campus Facility be capable of demonstrating cost effectiveness. Operations over the past 4 years have led to an approximate $600,000 deficit. It is hoped that user fees and cost reductions over the next couple of years can remove the deficit. The Campus Facility anticipates having the SPIRES Information Retrieval System operating for users within the next year. This new service will fill a major need. The library automation system BALLOTS developed in the environment provided by SPIRES and ORVYL is being developed and has the University Large Library Commitment. Some of the planned changes on the 360/67 entail optimizing the systems which are presently run there. A major new service to be offered by the Campus Facility will be an interactive version of a subset of the PL/1 language. This will be especially interesting to users of the current ACME system.

Advantages of Potential Merger:

1) Availability of an increased range of services to the Medical School users, including batch service and additional languages;

2) Participation in the system which the University is committed to support would increase the financial support available for computing. The University Computing Fund used for unsponsored research and student computing has been running approximately $700,000 per year. The Medical School use of such funding has been limited to approximately $15,000 per year, primarily due to the availability of ACME. The University's Computing funds have been declared to be unavailable for use on the ACME system since the primary focus of the University must rest with the support of a central system;

3) Data bases could be easily shared among various disciplines within the University;

4) The new SPIRES Information Retrieval facility would be available to medical users;

5) The service center would not be totally dependent upon one source of funding such as NIH with respect to medical funding. Thus it would be less sensitive to use by a single group of users;

6) There may be long term advantages associated with economy of scale with respect to hardware, staffing, and physical plant;

7) The Medical School would not have to assume full financial responsibility for a sizable computing facility such as ACME; the risk would be shared among all schools within the University for a central facility.

Disadvantages of the Potential Merger:

1) The realtime services which already exist on the ACME system do not exist on the Campus Facility. ACME is currently attempting to develop a real time support system which would be host-machine independent. Campus Facility may add it as a service.

2) ACME type service has a strong personal relationship quality which may be more difficult to attain in a system shared by several thousand users;

3) The Campus Facility is located more than a quarter mile from the Medical School. Although this distance may sound small, it is a physical obstacle which does present potential interaction problems, despite the terminal service available;

4) Current disk rates and the ORVYL file system will make disk storage more expensive for medical users that the current ACME rates. See the subsequent section on Cost Considerations;

5) A large facility serving several thousand users may have less flexibility in terms of changing its systems than a smaller facility serving approximately 300 user projects;

6) ACME users would have to translate their programs to the form of interactive PL/1 mounted on the Campus Facility. Hopefully the conversion cost can be minimized with translation aids prepared by the facility.

Comments on Cost Comparisons between Campus and ACME Services:

Cost comparisons have been difficult to draw between Campus and ACME Facilities due to the disparate nature of the facilities and the accounting algorithms. Three of the FORTRAN programs used in the ORVYL capacity study were translated into PL/ACME. The three were of different types: A matrix multiplier which is heavily compute-bound, a file writing program, and a psuedo parser which is primarily a string manipulator with a great deal of 2741 output. Considering only the charges for CPU time and terminal access time under both systems, the compute-bound job would cost 42% less on Campus Facility than on ACME assuming that ACME is used during hours of heavy activity. The other two programs (which were heavily dependent on output speeds) provided roughly equal costs at Campus and ACME. These cost statements assume that ACME is charged at 2-1/2¢ per pageminute plus $3.75 per terminal hour on the old 8 microsecond bulk core. The Campus rates were the standard $10 per CPU minute on ORVYL, plus $3.50 per terminal hour. One factor which is difficult to evaluate is the extent to which the CPU plus terminal access at Campus reflects the total cost of the job. Averaging all user charges for fiscal year 1971 at the Campus Facility, a total of 68% was derived from CPU usage and terminal access. This means that another 32% of the income was derived from disk storage, printing, card punching, card reading, off-line plotting, and use of the WYLBUR text editor. The point is that 32% of the income comes from sources other than those used in the above comparison.

At ACME the charges to users other than pageminutes and terminal access cover disk storage and terminal rental service. ACME's terminal rental service includes an add-on to cover general services to the community whereas the Campus Facility terminal rental rate covers only costs. The rate is $135 per month plus $4 to $13 for telephone lines on the Campus Facility versus $225 per month on ACME for a private 2741 terminal. The disk storage rate at ACME is 1¢ per track per day versus Campus Facility rate recently announced of 2¢ per track per day. Since ACME has moved to a faster bulk core, it can now provide more computing per dollar than the old 2 1/2¢ per pageminute rate permitted; the effect of the new core will vary by types of use. Cycle intensive users will use 50% to 70% of the pageminute usage encountered with the slower bulk core. Data input via terminals and program development will require about the same number of pageminutes on the new core.

The cost comparisons are difficult to make. It is clear that compute-bound jobs can be executed more efficiently on the Campus Facility than on the ACME configuration. I/O bound jobs tend to run at roughly comparable costs on each facility. On the basis of these findings, it appears that short term economics should not be the basis for any decision with respect to merger or lack of merger.

Dist: Staff/All

APPENDIX B

ACME System Core Timing Results
(AMPEX vs. IBM)

ACME Note

WCTR-1
Regina Frey
November 29, 1971

ACME System Core Timing Results (AMPEX vs. IBM)

Introduction:

A set of programs were collected for the purpose of measuring the effect on the ACME system of substituting AMPEX 2.5 microsecond core for IBM's 8 microsecond Large Capacity Storage.

Essentially, these programs were selected to answer three questions:

1. Whether the AMPEX core boxes do indeed have a 2.5 microsecond cycle time.
2. The performance improvement on a hopefully representative set of PL/ACME programs.
3. Whether the core substitution would have any effect on the maximum possible transmission rate between the 1800 and the 360.

Comparative Core Timings:

An OS batch program was written in assembler language which measured the true cycle times of the IBM 2050 'fast' core, the IBM 2361 LCS, and the AMPEX core boxes. The time required in each case to perform a series of fixed and floating point operations was measured.

The results are given in Table 1. The program contains four loops. The first measures true cycle time; the last three time loops containing fixed point arithmetic, short floating point arithmetic, and long floating point arithmetic instructions.

That each core box performed according to specification was proved in the first operation. The operation consisted of little more than ten million STore instructions. Each ST requires 2 core cycles for completion. Thus if the core cycle is 2 μs, then each ST will require 4 μs, ten million of them require $4 \times 10 \times 10^6$ μs or 40 seconds.

Table 1. Core Timing Results (Seconds)

Operation \ Core	IBM 2050 (Fast Core)	AMPEX (Bulk Core)	IBM 2361 (Bulk Core)	AMPEX 2361 (%)	2050 AMPEX (%)
Fixed point STore	40.29	50.46	161.65	31	80
Fixed point arithmetic	111.10	121.11	220.17	55	91
Short floating arithmetic	118.14	128.15	214.36	60	92
Long floating arithmetic	287.16	302.19	440.25	69	95

Notes on Table 1:

1. The AMPEX times are the averages of two runs.

2. All figures include overhead time for instruction loop control and fetch/conversion of the interval timer.

3. Time intervals were calculated to the nearest one-hundredth of a second. The TIME SVC was used to obtain the contents of the hardware timer.

4. The operations performed in each loop were:
   a) Fixed point store: 10×10^6 ST instructions.
   b) Fixed point arithmetic: 2×10^6 sequences of L, M, A, S, D.
   c) Short floating arithmetic: 2×10^6 sequences of LE, ME, AE, SE, DE.
   d) Long floating arithmetic: 2×10^6 sequences of LD, MD, AD, SD, DD.

5. No index register was used in any of the instructions.

Representative PL/ACME Programs:

Seven PL/ACME programs were run with the IBM 2361 core and the AMPEX core. All of these programs were written by the ACME staff.

All runs were executed in single user mode. Module TEN1, written on 11/4 and 11/11, was used. The differences between the two versions of the module do not affect the results.

The program attributes are given below; the timing results are in Table 2. The performance improvement was calculated as the difference between IBM time and AMPEX time over the original IBM time.

Program	Attributes
CONVERGE	PDP-11 assembler. No terminal output. Moderate disk file I/O. Heavy string operations.
CM1	Matrix multiplier. No I/O operations, no strings. Totally compute-bound.
iotime	Disk file read and write sequential operations. Time was measured for reading and writing 100 records of one block each. The loop was repeated 10 times each run. Little computation. No terminal output.
lisptest	LISP test program. Light file and terminal activity. The program did not complete due to an error in the LISP garbage collector. Time was measured by eyeballing the machine room clock.
PLA_PL1	The PL/ACME to PL/1 translator. Heavy file and string activity. The program produced a page of terminal output and required four one-character terminal responses.
PLOT1	TV plotting program. No file or terminal activity. Light mathematical calculations. Heavily dependent upon the speed of the display.
randfile	Random disk file operations. Light computations; no terminal output. The program consists of three sequences: Write direct of 20 records with randomly assigned keys, each record 1200 words long; Read sequentially each of the randomly written records; Read randomly the 20 records 5 times for a total of 100 reads.

Table 2. PL/ACME Program Timing Results

Program \ Core Perform.	IBM 2361	AMPEX	Performance Improvement (%)
CONVERSE	5.7 min.	3.2 min.	46.9
CM1	6.1 min.	2.5 min.	59.0
lisptest	4.75 min.	3.0 min.	36.8
PLA_PL1	23.8 min.	17.4 min.	24.8
PLOT1	4.9 min.	4.0 min.	18.1
iotime:			
100 reads	13.2 sec	9.5 sec	28.0
100 writes	19.8 sec	14.4 sec	27.3
randfile:			
20 write direct	23.0 sec	15.8 sec	31.3
20 read seq.	71.7 sec	34.2 sec	52.3
100 read direct	49.1 sec	29.1 sec	40.7
		Average	36.5

The rather unexpected gains in the execution speeds of 'iotime' and 'randfile' require discussion. While they were included primarily for determining a base against which to measure the impending AMPEX disk drives, the results of this test provide some interesting information regarding the nature of the ACME file system.

Unfortunately, 'iotime' was executed only once with the IBM core, so while the times listed are the averages for 1000 operations (100 read/writes repeated 10 times), they may not in fact represent true average results. This statement is based on two facts: The times for the 10 repetitions did not vary greatly, but the differences between the AMPEX runs were considerable.

'iotime' was executed 4 times with the AMPEX core. The time required for 100 reads varied from 7.2 seconds to 14.7 seconds. For 100 writes, the variance was from 13 seconds to 17.4 seconds.

These broad ranges are due to the variability of the required disk head seek time (from near zero to a maximum of 130 milliseconds.)

Because of the ascendingly ordered nature of the ACME Space List, the average seek time should not be 60 ms, but 25 ms (time to seek to next contiguous cylinder). Total I/O time for an average read is 25 ms plus 12.5 ms disk rotation time or 37.5 ms. For a write operation, an additional complete rotational period of 25 ms must be added for an average time of 62.5 ms.

Subtracting these figures from the average times for a single read or write, we get these software overhead values:

	IBM	AMPEX
read	132 -37.5 94.5 ms	95 - 37.5 57.5 ms
write	198 - 62.5 135.5 ms	144 - 62.5 81.5 ms

The values are somewhat inflated since the times required to update the index and to type the time on the terminal have not been subtracted. But clearly the unexpected savings while performing disk I/O have been explained, and equally clearly the file system software could be optimized.

'randfile' was executed twice with the IBM core, four times with the AMPEX core. All comments on 'iotime' apply as well to 'randfile' except that the results of the individual runs were not as variable.

The phenomenal savings on the read sequential operation can be explained by the fact that the record keys were distributed randomly throughout the

file index and consequently a considerable amount of in-core index searching was necessary for finding the next sequential record.

1800 Communications:

Little improvement was expected in the 1800 communications transmission rate since the essential routines (EIGHTNØØ, RW18ØØ, YIELD) were already located in the 2.0 μs core.

To test the hypothesis, one of Lee Hundley's 1800 test routines (READALOT) was executed before and after the core switch. The purpose of the tests was to establish the conditions under which data overruns (data arriving too soon for the 360 to process) would occur.

READALOT accepts as parameters the number of 1800 input lines (N), the sample interval in milliseconds (TIME), and the number of 360 buffers assigned to each line (BUFS). Buffer size was fixed at the maximum permitted, 250 points. After experimentation, we decided to leave BUFS at its maximum value (20) and to vary only N and TIME.

The following information was gathered from the IBM 2361 test:

1. N=8 and TIME=1 (8000 points/sec) will crash the 1800.
2. N=7 and TIME=1 (7000 points/sec) will cause data overruns.
3. N=12 and TIME=2 (6000 points/sec) will not cause data overruns.

Running as a single user and performing no calculations on the collected data, the only significant overhead was the time required for YIELD to service the commutator (i.e., look for another user and ultimately return to the only active one). Therefore, to determine the approximate amount in excess of 6000 points/sec at which overruns would occur, we inserted DELAY(0) statements in the program following each CALL READ (One DELAY(0) forces one yield to the commutator and wastes one time slice). With N=12 and TIME=2, two DELAY(0) statements resulted in overruns.

The same program, executed in AMPEX core, gave these results:

1. N=7 and TIME=1 (7000 points/sec) will not result in overruns.
2. N=7 and TIME=1 with two DELAY(0) statements will result in overruns.

Thus the maximum possible data rate was increased by approximately 1000 points per second or roughly 15%.

The second experiment was concerned with the question of whether EIGHTNØØ could execute properly in 2.5 μs core. About six months ago, EIGHTNØØ was moved from the 8 μs core to 2 μs core when it was discovered that the channel commands contained within EIGHTNØØ could not be decoded

fast enough and channel data chaining checks occurred. This condition prevailed only if the buffer size was extremely small.

A special link edit off TEN1 placed EIGHTNØØ in 2.5 μs core. Tests on this module gave these results:

1. A buffer size of one no longer caused data chaining checks, but overruns consistently occurred, even at low data rates. At 1000 points/sec on the line, the 1800 will crash.
2. A buffer size of two points or greater will execute properly.

However, it is not recommended that EIGHTNØØ be moved out of our fast core. AMPEX performance at its best is still 80% of the maximum on a Model 50. Moving EIGHTNØØ would decrease our maximum possible transmission rate (has not been tested).

Summary:

It has been confirmed that the AMPEX core does run with a 2.5 microsecond cycle time. Fixed point operations execute 2 to 3 times faster; floating point operations roughly 1 1/2 times faster than in 8 microsecond core.

Total time savings is heavily dependent upon the nature of a PL/ACME program. Terminal-bound or otherwise I/O dependent programs will see little increase in execution speed. Compute-bound programs may execute as much as 2 1/2 times faster.

The time slice allocated to each executing program remains as before. Thus, terminal response time will in many cases be the same, but since more computation is possible within each time slice, total execution time for a program will decrease. A sample of PL/ACME programs executes from 18 to 60% faster. The average was 36.5%.

While some improvement is realized for disk file operations, the gain may be unnoticed due to the yield to the commutator (other users) at the start of each I/O operation and the resultant wait by a user until his turn again arrives.

The maximum 1800/360 transmission rate has increased by about 15%. A greater increase was not expected since the 360 communications program had already been located in 2 microsecond core.

Dist: Prog/All/D. Phillips/C. Dickens

APPENDIX C

Results of Three Compaction Algorithms

The test was performed during a File System Analyzer run on all user data sets, February 28, 1972.

CODINGS USED BY EACH COMPRESSION ALGORITHM TO BUILT BITSTRING*

	COMPAC1	COMPAC2	COMPAC3
WORD IS ZERO	00	00	-
WORD IS UNDEFINED	01	01	-
WORD HAS VALUE	1	10	0
WORD IS REPEAT OF LAST WORD	-	11	1

TOTAL NON-NUMERIC WORDS = 16,532,183

TOTAL EMPTY (zero) WORDS = 5,184,105

The resultant savings from the application of each algorithm is stated below. Percentage figures were computed as the total storage requirement after application of the algorithm over the current storage requirement. TOTAL WORDS WHEN LESS refers to the inclusion of a file only when its 'compacted' size is less than the original size.

TOTAL WORDS IN ALL ACME NUMERIC DATA FILES	7,783,794	
TOTAL WORDS USING COMPAC1 ON ALL FILES	4,395,400	(56%)
TOTAL WORDS USING COMPAC1 ONLY WHEN LESS	4,314,484	(55%)
TOTAL WORDS USING COMPAC2 ON ALL FILES	3,661,950	(47%)
TOTAL WORDS USING COMPAC2 ONLY WHEN LESS	3,612,031	(46%)
TOTAL WORDS USING COMPAC3 ON ALL FILES	3,818,520	(49%)
TOTAL WORDS USING COMPAC3 ONLY WHEN LESS	3,783,314	(48%)

*The bitstring describes the characteristics of the values in a numeric array. It is stored on disk along with sufficient data to reconstruct the array. Repeated, undefined, or zero data is omitted from storage.

APPENDIX D
ACME 360/50
COMPARISON OF MEAN TIME BETWEEN FAILURES
JULY 17, 1969 - APRIL 30, 1972
(IN HOURS)

HARDWARE

	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Annual Average
1969-1970:	113.3	55.3	25.2	31.3	56.0	167.3	47.4	39.5	58.7	59.6	83.0	34.5	64.3
1970-1971:	72.4	34.7	176.0	362.0	704.0	104.0	218.7	364.0	182.0	78.2	103.4	176.0	214.8
1971-1972:	244.7	178.0	368.0	39.4	64.2	60.3	56.2	143.8	175.0	147.7*	147.7*	147.7*	147.7*

ALL FAILURES INCL. HARDWARE

	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Annual Average
1969-1970:	40.0	33.2	17.7	26.5	48.0	44.0	39.0	25.2	27.0	29.8	60.4	22.6	34.4
1970-1971:	29.0	24.3	54.1	181.0	234.7	38.3	54.7	80.9	66.2	37.1	80.4	88.0	80.7
1971-1972:	146.8	142.4	73.6	33.8	54.6	40.2	52.0	79.9	116.7	82.2*	82.2*	82.2*	82.2*

Underlined Figures = Best mean time to failure as compared to same period of each year.

* (May - July, 1972) Projected mean time to failure based upon first nine months total of August 1971 through April 1972.

APPENDIX E

Proposal for Small Computer Service by ACME

ACME Note

PSCS-1
Bob Stainton
March 21, 1972

Proposal for Small Computer Service by ACME

The rapid decline in the price of mini-computers has led to an increase in the number of these computers installed at the Medical Center. This memo describes the services which could be provided to these computers by the ACME facility.

The service is summarized as follows:

1. Spooling service--
   A. Accept data - 20 hours a day
   B. Send data (or processing modules) - 20 hours a day

2. On line service (while the user is actually logged on to ACME)--
   A. Retrieve data from the spool
   B. Write data (or processing modules) to the spool for later use by the mini-computer
   C. Read and write directly to the mini-computer

3. All services of an ACME typewriter terminal.

4. High level language processors.

Spooling Service

Spooling (Simultaneous Peripheral Operation) refers to a procedure which has become popular with large-scale third generation computers. It is exemplified by a card reader which is always ready to accept cards, even though these cards may not be processed by a user program until several hours have passed.

Our early experience with 2741 terminals has shown that their usefulness takes a quantum jump as soon as a computer system is installed which is continuously available to "answer the telephone".

Our proposal is to provide a computer system which is always (20 hours a day) available to take data from the user's mini-computer. Our definition of mini-computer is any device which is able to conform to the requirements of the communications protocol. The data will be held on a special disk system, and retrieved when the user "logs-on" to the ACME system and runs a program. In this way a research scientist may set up an experiment which may run for several hours during the night. The next morning he may "log-on" and run a program which processes the data generated by that experiment.

Another service of the spooling system is the ability to provide storage for "processing modules" which can be called by the mini-computer. The relationship between the mini-computer and the ACME system in this instance can best be described by an analysis of the classic "pen tracking problem".

In order to draw a line by means of a "light pen", a tracking cross is displayed on the screen of a cathode ray tube at the location where the "pen" is pointing. As the "pen" moves, the cross is no longer in the center of vision of the pen, and a computer interrupt takes place. The computer now re-establishes the cross in a new location.

To accomplish this smoothly requires a fast response and a large amount of data transfer. The response must be fast, or the cross will appear to drag as through a viscous fluid. The constant re-writing of the display requires the transfer of a large amount of data.

The conventional solution to this problem would be to use a very high speed communications line between a large central processor and the remote screen. This would ask the communications line to do that which it is least able to do, namely, provide fast response with large volumes of data.

A better solution is to employ a local mini-computer at the screen which produces the rapid response necessary to accomplish the "pen tracking". In this solution, a low speed communications line is used, and only the location of the tracking cross is sent to the large central computer. This information may be saved for later analysis or processed for a real time response.

In the medical research environment, the local mini-computer would contain that part of the software necessary to provide immediate reaction to the stimulus of the experiment. This software is contained in a replaceable "processing module" which also directs the sending of partially processed data to the ACME system for storage and statistical computation.

The replaceable "processing module" may be changed for individual experiments, or a new module may be loaded dynamically as the life of an experiment progresses.

These "processing modules" may be compiled in the ACME system and saved on the spooling system for later call by the mini-computer. A list of experimental parameters may also be stored on the spool and played back as data over an extended period of time.

On Line Service

The ACME user would be able to access data which has been previously placed on the spool by using a special "OPEN FILE" statement. The data may then be accessed with "READ FILE" statements as a sequential data file. Similar "WRITE FILE" statements may be used to write data (or processing modules) to the spool system for later use by the mini-computer.

An option would also be provided to bypass the spooling system and communicate directly with a running ACME program, using the current directory mechanism. This allows the same real time interactive service which has been available in the past.

Service of an ACME Terminal

As a convenience, it is realized that the "teletype" console of a mini-computer should be able to act as if it were an ACME terminal, so that the user need not use a separate 2741 terminal in order to use the ACME system. The user would also be able to "log-on" and run programs automatically, under control of a program in his mini-computer.

High Level Language Processors

We will attempt to provide a hardware-independent language for writing "processing modules". Translators for this language to produce object code for the most popular mini-computers would be produced. This would provide an ease of programming not found on stand-alone systems, as well as a medium for sharing programs among individual researchers.

Implementation

Implementation would require several loosely related projects:

1. The spooling system, housed in a separate mini-computer so that it can operate during maintenance hours for the large central computer.
2. A switching system, for attaching a given user to an ACME port, a real time data port, or the spooling system. As a by-product, we hope to allow any mini-computer in the system to communicate with any other mini in the system.
3. A communication system to transport the data and verify its correct receipt, with as little effort on the part of the mini-computer program as possible. We hope to provide a parallel, demand-response interface to the mini-computer, which appears to its program as a device similar to a tape drive.
4. High-level processors to provide an easy way of writing programs for the mini-computer.

Dist: Staff/All